WALKER

SEVENTEENTH
EDITION

500 800

THE BUILDING ESTIMATOR'S REFERENCE BOOK

A Practical and Thoroughly Reliable
Reference Book for Contractors and Estimators
Engaged in Estimating the Cost of and Constructing
All Classes of Modern Buildings

EDITED BY
McClurg / Shoemaker
Architects and Engineers
CHICAGO, ILLINOIS

FRANK R. WALKER COMPANY
PUBLISHERS **CHICAGO**

We will be grateful to readers of this volume who will kindly call our attention to any errors, typographical or otherwise, discovered therein. We also invite constructive criticism and suggestions that will assist in making future editions of this book more complete and useful.

FRANK R. WALKER COMPANY

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BY

FRANK R. WALKER COMPANY

Publishers of
Practical Accounting and Cost Keeping for Contractors
Hogg's Wage Tables
Bookkeeping Systems and Forms for Contractors

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PREFACE

In compiling this Seventeenth Edition of "The Building Estimator's Reference Book" we especially noted three trends altering some traditional procedures in estimating.

The first is the rise of labor costs at an ever increasing rate. An estimate based on last year's cost records, whether compiled from personal experience or from published square foot tables, will find the contractor's profit preempted by labor's escalating rates. This edition retains the blank spaces alongside the cost breakdowns so an estimator can note any change and keep his own records current and accurate.

The second trend is the high cost of borrowing money. A contractor must complete each phase of the work as scheduled to avoid partial payments. Drawings and specifications must be clearly agreed upon to avoid delays over extras and changes. Contracts must be explicit or final payments may be held up in lawsuits. This edition contains two new chapters written to define the exact role of the contractor, to acquaint him with the various types of contracts, the basics of reading blueprints, and the advantage that can be taken by using many of the published business and contract forms available today.

The third trend is towards system type building procedures. One can serve a meal from already prepared foods or by starting with all the basic ingredients. Prepared foods will cost more unless the labor saved is put to more productive use. Similarly, prefabrication of building components won't lead to lower costs unless the contractor uses it in a knowledgeable way. A thorough study of the Critical Path chapter will point up the necessity of proper scheduling if one is to remain competitive.

The continuing changes in building operations mean we must be ever more alert to the information passed on to us by the contractors, manufacturers, trade associations, appraisers, educators, architects, and engineers who use this book and who have cooperated in re-editing this edition. It is this cooperation that has kept "The Building Estimator's Reference Book" in publication for over fifty-five years and we thank all of you for your continued interest and support.

THE EDITORS

McCLURG/SHOEMAKER

Chicago, Illinois

1970

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IMPORTANT

How to Obtain the Best Results From the Estimating and Cost Data in This Book

In compiling a book of estimating and cost data that is used in all parts of America and many foreign countries, it is impossible to quote material prices and labor costs that will apply in every locality without some computation on the part of the user.

For this reason all labor costs state the quantity of work a man should perform per hour or per day, together with the number of hours required to complete a certain unit of work. In each instance a certain basic price has been used, but the user is urged to insert local wage scales and material prices, as by so doing accurate estimates are sure to result.

This method of tabulation has been used throughout the book, making it easy for any person to insert local prices and obtain dependable estimates.

An example of the method used is given below, taken from page 888 under the heading "Framing and Setting Floor Joists."

When framing and placing wood floor joists up to 2"x8" in buildings of regular construction, a carpenter should frame and place 550-600 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	13.9	$	$	$6.75	$93.83
Labor	4.5	....	....	5.00	22.50
Cost per 1,000 ft. b.m....	18.4		$		$116.33

In order that this data will prove of the utmost value to YOU in your business, the blank spaces have been left for you to insert your local wage scale as shown below:

	Hours	Rate	Total	Rate	Total
Carpenter	13.9	$8.50	$118.15	$6.75	$93.83
Labor	4.5	6.00	27.00	5.00	22.50
Cost per 1,000 ft. b.m....	18.4		$145.15		$116.33

By inserting local prices in all tables, you will be surprised how accurate the estimate will really be, thus eliminating radical estimates which are usually accompanied by bids that are ridiculously low or unreasonably high.

The success of your entire business depends upon the correctness of your estimates. YOU CANNOT BE TOO CAREFUL!

FRANK R. WALKER COMPANY

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The method of tabulation has been used throughout the book, making it easy for any person to insert local prices and obtain dependable estimates.

An example of the method used is given below, taken from page 880 under the heading "Framing and Nailing Floor Joists."

When framing and placing wood floor joists up to 2"x8" in buildings of regular construction, a carpenter should frame and place 550-600 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	13.7	$	$	74.17	$10.83
Labor	6.3			5.00	32.50
Cost per 1,000 ft. b.m.			$		$16.33

In order that this data will prove of the utmost value to YOU in your business, the blank spaces have been left for you to insert your local wage scale as shown below:

	Hours	Rate	Total	Rate	Total
Carpenter	13.7	74.17	$10.16	84.17	$10.83
Labor	6.3	5.00	27.00	5.00	32.50
Cost per 1,000 ft. b.m.			$16.16		$16.33

By inserting local prices in all tables, you will be surprised how accurate the estimate will really be, thus eliminating radical costs which are usually accompanied by bids that are ridiculously low or unreasonably high.

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THE BUILDING ESTIMATOR'S REFERENCE BOOK

CHAPTER I

THE ROLE OF THE CONTRACTOR

The best of buildings are the combined efforts of several parties. Traditionally these have been centered on the owner, who is, or represents, the user of the building; the architect, who designs the building; and the contractor, who constructs the building. The owner may have as his consultants a realtor, both for land purchase and building management, and the financiers, who may provide short term cash for building construction and later the final long term mortgage when the project is completed.

The architect consults with the structural and mechanical engineers, the site planners and the interior space planners, any or all of which may or may not be part of his immediate office. He also consults with the governmental agencies who control zoning, building codes and city planning, although he usually does not take out the building permit. He also relies on the cooperation of the producers, who manufacture the products which he designs into his structure.

The contractor has as his team the various subcontractors and the producers and suppliers of the equipment, materials, services, appliances, tools and machinery called for by the architect and required to complete the job. The contractor must also cooperate with the governing officials as he must take out all building permits and conduct his operation without violating local laws governing everything from blocking traffic to waking up the neighbors. And then there are also the trade unions, the local utilities, and the ever-necessary bankers who, we hope, are always friendly but often are not as sympathetic as we'd like.

With the tremendous boom in construction the exclusive club of owner-architect-contractor has been forced to let in others, some welcome, some not, so that the triangle has now become more of a circle. Thus, in large projects today the owner-user may be the large landowner who wishes to develop his holdings; government wishing to rebuild the inner city; or a large insurance company that needs to keep its investments active. The architect's concern may no longer be the individual building but an entire complex, a neighborhood, a whole new town. And the general contractor may find himself in demand less for his craftsmanship abilities than for his managerial capabilities.

But no matter how small or how complex the project is, someone must have a need (owner), someone else must develop the needs into satisfactory plans (architect), and someone must interpret the plans into an actual building (the contractor).

GETTING THE CONTRACT

Construction contracts are usually awarded in one of two ways —competitive bidding and negotiation.

Competitive bidding is the method used in the majority of instances, but it is only truly effective when complete working drawings and specifications are available and when contractors are screened so all who bid are of the same caliber. To be asked to bid on sketchy plans and vague specifications is generally a waste of time for the more capable contractors for they will most always be underbid by those who will sacrifice quality for price. To get on the bidding list of an architect's office that is known to produce detailed drawings and tight specifications, and insist upon their being carried out, is one of the most valuable contacts a contractor aspiring to fine work can make. The architect has already spent many hours working with the owner making most of the critical decisions, and by the time bids are taken, the contractor's responsibilities are clearly set forth. He can proceed, if awarded the contract, knowing that the finished project will most probably satisfy the owner, and satisfied owners are probably the most valuable asset a contractor can have.

In private work the architect, often with the owner's help, will limit the list of bidders so you can judge your competition and know that if your price is low and reasonable you will get the contract. Public work must usually be open to any "qualified" bidder, and "qualifications" are generally concerned more with financial status than reputation for quality. In order to propose a low bid against unknown competition a good contractor must

be certain his organization can bring to the project experience and efficiencies uniquely his own. Otherwise he most certainly will be underbid by those desperate enough for work to bid without profit just to get a job.

Private work is sometimes announced in the newspaper or listed in trade publications, but a real estate agent or a banker can often steer a contractor to jobs when he is not contacted directly by an architectural firm. Public work is almost always publicly advertised.

Often to get on a bidding list a contractor must be prequalified. There are various ways this is done, by organizations, governmental bodies and banks but, in general, the information that must be submitted will follow that contained in AIA Document A-305 "Contractor's Qualification Statement." This requires the firm, whether it is a corporation, a partnership or an individual, provide details on: length of time in business, names of principals, percent of work performed by own staff, record of and reasons for any past failures to complete a job, major projects now under construction, major projects completed in past five years, a record of experience of firm employees, bank references, trade references, name of bonding company, and a statement of financial conditions including current assets, liabilities and the auditor's name. However, often just being a member in good standing of a local contractor's association plus a bank reference will satisfy an inquiry.

Once on a bidding list, a contractor will receive an Invitation to Bidders for each prospective job. This form will include such information as job location, type of proposal, the number of sets of drawings and specifications to be furnished to bidders, what to do should discrepancies or errors be found in drawings and specifications, bulletins to be issued later, when and how bids will be opened, and when and where bids are due. A proposal sheet is usually attached so only the blanks need be filled out, but sometimes the contractor must furnish his own.

Often the Invitation to Bid is accompanied by an Instruction to Bidders further defining job restrictions such as completion dates, visiting job site, special conditions, etc.

Bid deposits may be required, the amount being either a Lump Sum or a percentage of the proposal. The Bid Bond guarantees that the contractor bidding, if awarded the contract, will enter into the contract and furnish a Performance Bond, if required. If he does not honor his bid he forfeits the amount of the bond, or the difference between his bid and the amount the owner can contract the work for with another contractor, whichever sum is less.

Bid Bonds and the latter Performance, Material and Labor and Material Payment Bonds are usually encountered in public work, often waived in private work where the contractor's reputation is deemed sufficient and the cost of bonds unwarranted. The cost of the Bid Bond is a cost borne by the contractor. Performance Bonds, unless made a part of the contract, are usually billed to the owner.

The other type of contract, one that is negotiated, allows the owner control over the selection of his general contractor. It is often used on complex work, i.e., remodeling jobs where the space is occupied and must be done piecemeal; interior work where strict control of subcontractors is desired; contracts in which mechanical equipment is a major factor and owner may prefer one manufacturer over another; and work which must proceed in great haste where the architect may not be able to produce complete plans in the time allotted and work will be let in sections: foundation work, then steel framing, then masonry, etc. Often the contractor will proceed as with bid jobs in submitting a Lump Sum price, usually on the safe side and known as an upset or guaranteed figure. This will sometimes include the contractor's profit, but often he will be reimbursed for that which he has spent in completing the work and his profit and overhead will be a stated fixed dollar amount or a percentage of the job total.

THE CONTRACT DOCUMENTS

Once it is determined which contracting firm is to do the job, a formal contract will be drawn up. The Contract Documents will include the Owner-Contractor Agreement; the General Conditions of the contract; Supplementary Conditions of the contract (if any); the Working Drawings, giving all sheet numbers with revisions; Specifications, giving page numbers; and Addenda or Bulletins issued prior to contract. After the contract is signed, any changes are added as Modifications to Contract and would take the form of written amendments, Change Orders or architectural interpretations.

The Owner-Contractor Agreement is a legal affair, but for many jobs standard forms are used. If the architect furnishes the Owner-Contractor Agreements he will most probably use one printed by the American Institute of Architects. These are:

a) The Stipulated Sum Agreement A-101, five pages long or A-107, a shortened form three pages long.

b) The Cost of the Work Plus a Fee Agreement A-111, nine pages long.

Both the above assume that the AIA Document A-201, "General Conditions of the Contract for Construction," 17 pages long, is made a part of the contract. These 14 conditions are discussed later in this chapter.

The Stipulated Sum Agreement will include the date of the agreement, the owner's name, contractor's name, the description of work, the architect's name, the time of commencement and completion, final payment and a list of the contract documents.

The Cost Plus a Fee Agreement will include date of agreement, owner's name, contractor's name, description of work, architect's name, the contractor's duties and status, time of commencement and completion, cost of work and guaranteed maximum cost (this may be deleted and if included may be supplemented by a provision for distribution of savings), the contractor's fee, provisions for changes in the work, reimbursable costs, non reimbursable costs, discounts, rebates and refunds, subcontractors, accounting records, applications for payment, payments to contractor, termination of contract and a list of the contract documents.

For less complicated Stipulated Sum contracts, where the contractor furnishes the form, one of the forms published by the Frank R. Walker Company may be useful. These include a one page proposal form #147 which includes an acceptance paragraph for the owner to sign to make a short contract; a one page contract agreement, form #158; and a longer four page agreement (form #160) which covers many of the provisions found in the usual general conditions.

Large corporations and governmental bodies will usually have contracts drawn up by their legal staffs. The contractor may want his own lawyer to review these contracts.

The General Conditions of the Contract usually refer to the American Institute of Architects Document A-201. These are often accompanied by Supplementary Conditions which modify and extend the General Conditions. Sometimes these two are combined and rewritten in a form more exactly fitting the special job conditions. But in any case, they set forth the rights, responsibilities and relations of all parties to the contract and every contractor should be thoroughly acquainted with them.

The latest edition of the AIA form contains fourteen articles. Briefly they cover the following:

Article 1. Defines the contract documents, the work, the project, the execution, correlation, intent and interpretations of the con-

tract documents, and sets forth the copies and ownership of these documents.

Article 2. Defines the architect and his administration of the contract. (A further discussion of administration is included later in this chapter.)

Article 3. Defines the owner and the information and services required of him.

Article 4. Defines the contractor; his responsibility to review the contract documents; his supervision and construction procedures; his furnishing and control of labor and materials; his responsibility for a warranty, for taxes, for permits, fees and notices; cash allowances, if any; the furnishing of a superintendent; his responsibility for those performing the work; the preparation of a progress schedule; the maintenance on the job site of drawings and specifications; the preparation of shop drawings and furnishing of samples; the use of the site; cutting and patching of work; cleaning up; proper channel for communications, and the indemnification of both owner and architect against all claims, damages, losses and expenses within the limits set forth.

Article 5. Defines the subcontractor, the award of subcontracts, subcontractual relations and payments to subcontractors.

Article 6. Sets forth the owner's right to award separate contracts, the mutual responsibilities of contractors, the problems of cutting and patching under separate contracts and the owner's right to clean up.

Article 7. Includes miscellaneous provisions such as the law of the place, successors and assigns, what constitutes written notice, how claims for damages are to be made, right of owner to require performance and labor and material bonds and how they will be paid for, owner's right to carry out the work if contractor defaults, payments of royalties and patents, tests that may be required, interest on money not paid when due, and arbitration of claims and disputes.

Article 8. Defines contract time, progress and completion and delays and extensions.

Article 9. Discusses payments and completion sum, the filing of a schedule of payments to be used as a basis for contractor's applications, progress payments, certificates for payment, payments withheld, failure of payment, and substantial completion and final payment.

Article 10. Covers protection of persons and property including safety precautions and programs, safety of persons and property, and emergency precautions.

Article 11. Lists the insurance requirements including contractor's liability insurance, owner's liability insurance, property damage insurance and loss of use insurance.

Article 12. Covers changes in the work, including change orders, how to file for claims for additional cost or time, minor changes in the work and field orders.

Article 13. Discusses uncovering and correction of work and acceptance of defective or non conforming work by the owner.

Article 14. Discusses termination of the contract by the contractor or by the owner.

The Supplementary Conditions may include two lists; those that amend the General Conditions and those that make additions to it.

SETTING UP THE JOB

Having been awarded the contract, the general contractor must then proceed to sign up his subcontractors. The standard AIA Owner-Contractor Agreement calls for the successful bidder to submit a list of subcontractors for approval prior to award of contract, and the owner and architect must object at that time to any firm on the list. If there is an objection, the contractor has two alternatives: to submit an acceptable substitute with the change in cost, if any, in which case the owner may at his discretion accept or reject the bid; or, the contractor may withdraw his bid without penalties.

Additional expenses occasioned by owner or architect rejection of subcontractors after award of contract, will be added by change order to the contract sum and paid for by the owner.

The contractor must also submit a progress schedule and a schedule of values based on his subcontracts.

The AIA agreement further sets forth the contents of agreements between subcontractors and the general contractor and the method of paying the subcontractors. AIA form A-401 may be used, or the shorter forms #133 or #144 published by Frank R. Walker Company.

The general contractor with the cooperation of his subs, the architect and owner, will file for and usually pay for all permits. Often it is necessary to have selected certain subcontractors before filing for permit as the permit may require the license number of certain trades.

The Supplementary General Conditions will usually set forth the initial site requirements—office, telephone, toilets, water, light, heat, barricades, temporary partitions, etc., which the general con-

tractor must provide. He must also make arrangements with local utilities.

CARRYING OUT THE WORK

The administration of the contract is clearly set forth in the AIA standard contractor agreements. The general contractor is responsible for executing the work in strict accordance with the contract documents and for turning the completed project over to the owner in full conformance with them. He must provide the continual supervision necessary to check all labor, materials and procedures to accomplish this.

The architect serves in an advisory capacity to both contractor and owner, interpreting drawings and specifications, approving shop drawings and samples, checking conformity of the job with contract documents, making periodic inspections to determine progress and approving payments to the contractors, and approving final acceptance of the contract. The architect will also have his consultants visit the site at certain intervals.

Often the owner will want more supervision than the architect includes in his standard contract and a "clerk of the works" is hired. He is usually paid by the owner, but works under the architect. He usually keeps complete job records and reports daily progress. But he does not supplant the architect and the architect's decisions are the final ones, nor does he relieve the contractor of his responsibilities of supervision.

In addition, public building inspectors will probably visit the site periodically and any objections they raise to apparent contradictions between codes and the contract documents should be reported in writing to the architect. At certain periods the contractor will be required to make tests and he must notify the proper authorities and the architect when these are to occur.

GETTING PAID

Applications for payment are usually made monthly. The Frank R. Walker Company form #591 is an excellent one for this. It provides a column for the list of subcontractor names, what work the contract is for, the total amount of each contract, the amount previously requested and finally the balance to complete. The bottom of the form provides a resume of total amounts less percentages retained, and a space for notarizing. Waivers of lien showing that the contractor has paid for all materials, labor and subcontractor billings are usually required to accompany the

request for payment. The Frank R. Walker Company has printed forms for a Contractor's Affidavit (#592) and Waiver of Lien (#593).

The architect then checks the application and if it agrees with what he feels to be proportionate to the amount of the contract, he will issue a certificate of payment. Walker publishes a certificate for payment (form #496) in duplicate. His decision in this may be reviewed by either the company writing the performance bond or the company supplying the interim financing. As all this takes time for the contractor to prepare, the architect to check and approve and the owner to process, the contractor must keep all his billings and payments current. With the high cost of money today, short term loans to tide a contractor over for a month because he didn't get around to filing a proper or complete request for payment can eat away at profits as surely as having to correct mistakes on the job.

Upon final completion and acceptance, the contractor should be prepared to file final waivers along with any written guarantees, certificates of inspections, operating instructions, etc., that may have been called for.

DEFINITIONS

In reviewing standard contract forms, certain terms may be used which have special meaning within the profession. Some of these are explained below:

Addenda—Modifications to the contract documents issued by the architect's office during the bidding period. Often identified as "Bulletins."

Alternates: Additions or subtractions to a contract sum for substitutions asked for by the architect, which the contractor must submit with his proposal.

Approved Equal: A rather loose term indicating that the contractor may substitute another product for that which the architect specifies, providing it is "equal" in all respects. It is well to accompany a proposal with a list of such substitutions upon which a contractor may have based his figure, as it is the architect not the contractor who has the final say as to what is "equal."

Bid: A proposal stating the sum for which the contractor will complete a project.

Bid Bond: A bond furnished by the contractor that guarantees he will sign a contract on the basis of his bid.

Cash Allowance: Sums set forth by the architect for specific items which the contractor must include in his proposal.

Upon completion of a job the contractor must make an accounting of these sums returning any unspent amounts to the owner. Often used for buying hardware, face brick, light fixtures, and other special items.

Certificate of Occupancy: Issued by a government authority authorizing occupation of a building.

Change Order: An authorization by the architect to change the basic contract because of additions or deductions from it.

Cost Breakdown (or schedule of values): A schedule prepared by the contractor showing how the contract sum is divided among the various divisions of the work, which is filed before work is started. The architect will use this as a basis for approving applications for payment and waivers. It should be accurate and kept up to date, reflecting any changes in the contract.

Extras: Construction costs outside of contract sum. A contractor should not proceed with any extras until a Change Order is issued by the architect.

Final Acceptance: When the owner accepts a project as complete.

Guarantee Bond: A bond assuring that the contractor will complete a project in accordance with contract documents including discharging all financial obligations. Also known as a "Performance Bond."

Letter of Intent: Written prior to drawing up complete contract documents to tell the contractor a formal agreement is forthcoming. Often this authorizes certain preliminary work such as filing for building permits and site clearance.

Liens: Legal claims against an owner for labor and materials for construction of a project.

Liquidated Damages: A sum agreed to by owner and contractor, chargeable to the contractor, for damages suffered by the owner because of contractor's failure to fulfill his contract obligations

Performance Bond: Same as guarantee bond.

Punch List: The architect's list of work yet to be done or to be corrected by the contractor.

Retainage: A percentage set forth in the Owner-Contractor Agreement to be withheld from each payment to the contractor. Usually 10%, reduced to a total of 5% upon substantial completion.

Separate Contract: A contract let by the owner directly to a contractor other than the general contractor. Usually for special equipment, landscaping, interior furnishings, etc.

Shop Drawings: Drawings prepared at the contractor's expense showing how specific items shall be fabricated and/or installed. These usually are prepared by the subcontractors and are standard for such items as steel, reinforcing, miscellaneous and ornamental iron, cut stone, millwork, partitions, door frames, etc. They must be submitted to the architect for his approval.

Substantial Completion: A state reached when the project is sufficiently complete to allow the owner to occupy it, but not necessarily finally accept it.

Superintendence: The work of the contractor's representative, not to be confused with that of the architect (administration) or clerk of the works.

Unit Prices: Amounts asked for on the proposal for furnishing materials per unit of measurement. That is, cost of concrete per cu. yd., floor tile per sq. ft., or steel per ton.

Upset Price: An amount agreed to by the contractor as a maximum cost to perform a specific project. Used on Cost Plus a Fee jobs.

Warranty: A guarantee furnished by the contractor or a manufacturer covering quality, workmanship and performance for a specified period.

~~FRACTION~~

Job No. 527

CERTIFICATE FOR PAYMENT TO CONTRACTOR

Certificate No. 3

Date July 14, 19--

TO Mr. John H. Smith
656 N. Main Street
Arlington, Illinois

$ 7,449.00

THIS IS TO CERTIFY, that

Andrews Construction Company----------

Contractor for General Work at 656 N. Main Street, Arlington, Illinois----------

is entitled to a Final payment of Seven Thousand Four Hundred Forty-Nine and no/100---------($7,449.00)----------Dollars under terms of this contract.

Received Amount of above Certificate.

Contractor

STATEMENT		
Contract	$23,112.00	
Extras	411.00	
TOTAL	$23,523.00	
Deductions	none	
TOTAL	$23,523.00	23,523.00
Total Comp. Wk.	$23,523.00	
Less Retention		
Prev. Payments		16,074.00
AMOUNT DUE		$ 7,449.00

FORM 306 FRANK B. WALKER CO., PUBLISHERS, CHICAGO MFD. IN U.S.A.

CONTRACTOR'S AFFIDAVIT

State of Illinois } ss
County of Cook }

Office of Andrews Construction Company
209 E. Elm St., Arlington, Ill.

---------Phillip H. Andrews----------

being duly sworn on his oath deposes and says that he is Sole Owner of the Andrews Construction Co. the contractor for the----------General Contract----------
for the building erected for---------John H. Smith---------- owner
on the premises described as follows, to-wit: property known as 656 N. Main Street, Arlington, Cook County, Illinois----------

All the bills for labor and material are fully paid and discharged--------No Exceptions----------

That he makes this affidavit for the purpose of procuring from-----John H. Smith, Owner---------
----------Partial---------- payment
of Seven Thousand Four Hundred Forty-Nine-------Dollars and ----no/100---------Cents
upon---------- contract for said labor or material or both

SUBSCRIBED AND SWORN to before me
this 7th day of July A. D., 19--

ANDREWS CONSTRUCTION COMPANY

By
Sole Owner

Notary Public

WAIVER OF LIEN
MATERIAL OR LABOR

State of Illinois } ss
County of Cook }

July 6 19--

TO ALL WHOM IT MAY CONCERN

Whereas we the undersigned----------Andrews Construction Company----------
have been employed by-----John H. Smith, of Arlington, Illinois, under General Contract
to furnish all labor, material, equipment and supervision required to complete the construction work----------
for the Building known as the Smith Store Building located at 656 N. Main Street in the City of----------Arlington, Illinois----------

Lot No. 41 Section 12 Township Euclid Range 16
County of Cook State of Illinois

NOW THEREFORE KNOW YE That the Andrews Construction Company---------- the undersigned for and in consideration of the sum of Seven Thousand Four Hundred Forty-Nine---------- Dollars and other good and valuable considerations the receipt whereof is hereby acknowledged do hereby waive and release any and all lien or claim or right to lien on said above described building and premises under the Statutes of the State of Illinois relating to Mechanics Liens, on account of labor or materials or both furnished, or which may be furnished, by the undersigned to or on account of the said----------General Contract----------
----------for said building or premises

Given under hand and seal this 6th Day of July A D 19--

ANDREWS CONSTRUCTION COMPANY

Witness:

By
Sole Owner (SEAL)

(SEAL)

CHAPTER II

INTERPRETING WORKING DRAWINGS AND SPECIFICATIONS

The owner's dreams and the architect's visions must eventually be put down in a form the contractor can use as a treatise for bidding and later construction in enduring materials. This form has developed into the dual one of working drawings and specifications. Basically, the drawings present the design, the location and the dimensions of a project. The specifications give the quality required.

The drawings are done in pencil or ink on tracing paper or cloth which is easily reproducible, and prints are delivered to the contractor. The architect retains the original drawings in his office.

The specifications, except in very small jobs when they may be incorporated on the drawings, are printed and bound separately. Both are made available to each contractor bidding the job. As bid periods are usually quite limited, it is the contractor's ability to interpret them that enables him to present a realistic and complete bid. This chapter presents an outline of what information a contractor should expect to find in a bid set and where it may be found.

THE WORKING DRAWINGS

Arrangement.—A typical complete project will find several drawing sheets, usually all of uniform size, bound into one job set. The first sheet should include a site plan, sometimes incorporating the roof plan plus the complete job title, and sometimes an index of the drawings. This will be followed by the sheets showing architectural details, usually in the following order: basement plan, first floor plan, upper floor plans, exterior elevations, sections, interior elevations and details.

The architectural sheets are followed by the structural set including footing and foundation plans, basement framing plans, floor framing plans, roof framing plans, and then the structural details. These are followed by the heating and ventilating plans;

then the plumbing plans and, finally, the electrical plans, eac starting with the lowest floor and working upward.

Each sheet should have a title block in the lower righthan corner with the sheet number (usually "A-" for architectural, "S- for structural, "M-" for heating and ventilating, "P-" for plumb ing, and "E-" for electrical); the number of sheets in each se (i.e., A-1 of 7); the date made plus each date it has been revise and the initials of the person or persons who drew and approve the sheet.

Revisions are sometimes listed outside the title block. Som architects, rather than revising a drawing once it is printed, wi issue supplementary drawings which must be attached to th appropriate set as they are issued.

Type of Drawings.—Most working drawings for building con struction are based on Orthographic Projection, that is, by parallel projection to a plane by lines perpendicular to the plan In this way, all dimensions will be true. If the plane is horizonta the projection is a plan; if vertical, it is an elevation for outsid the building, or a sectional elevation if through the building.

Of course, the only descriptive drawing which presents a build ing as the eye sees it is the perspective. But perspectives ar used mainly to study the building and present it to the client in form he can easily understand. A perspective is seldom usefu for presenting information on working drawings. However, som other pictorial presentations are helpful to the builder.

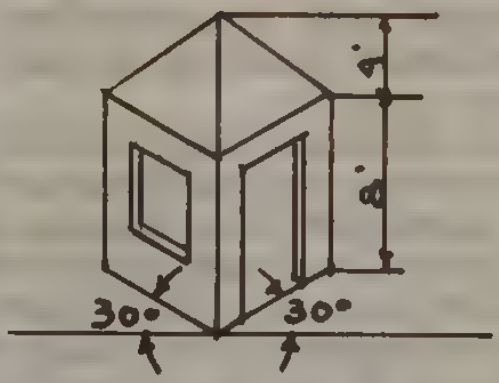
Two of these are the Isometric and the Cabinet Projectio Isometrics are drawings in which all horizontal and vertical line have a true length, and those lines parallel on the object ar also parallel on the drawing. Vertical lines are vertical, bu horizontal lines are set at 30° or 60°. Isometrics are often use for piping diagrams and to show complicated intersections suc as on sloped roofs.

Cabinet Drawings are those with the front face shown in tru shape and size as if it were an Orthographic Projection, but the simulate a perspective. The sides are shown receding at 45° an at ½ scale. Variations of this are Oblique Drawings, where th angle and side scale may be anything that best shows the objec and Cavalier Drawings, where the side scale is at the same scal as the front. Cabinet Drawings get their name from the fact tha they are often used for cabinet work.

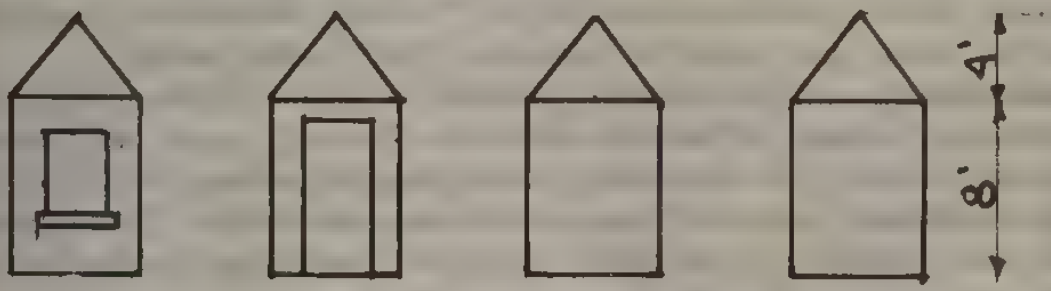
Scale.—The architect's scale, that is, the inch divided into ⅛s, 1/16s, 3/32s, is standard for building construction in the Unite States. The engineer's scale, with the inch divided into tenth is sometimes used in structural work or on site plans. Howeve

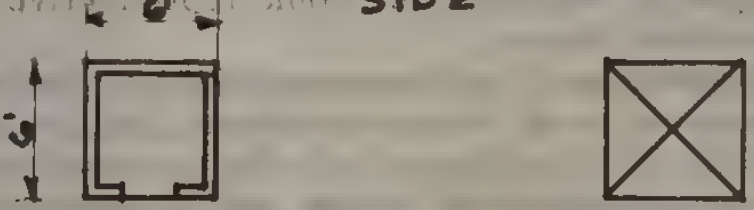
A Garden Shed

6' x 6' x 8' high
with peaked roof
Scale: 1/16"=1'0"

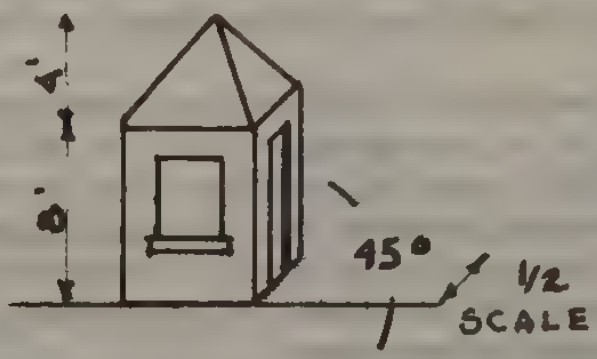


Shown As An, Isometric,





In Orthographic Projection,



And As A Cabinet Drawing

it is advantageous to have architectural, structural and mechanical drawings all at the same scale for the same job.

The metric scale is divided into centimeters and millimeters 2.54 centimeters equalling one inch. It is the common scale used in Europe.

Graphic scales are those devised by the draftsman and shown on the drawings with subdivisions comparable to the other scale. This is convenient if the drawing is to be reduced in size in reproduction and is meant to be scaled rather than dimensioned. It is seldom used on working drawings.

Plans and elevations are usually drawn at no less than $\frac{1}{8}$"=1'-0" plot plans at $\frac{1}{16}$"=1'-0". Complicated plan areas, such as toilet rooms, are usually repeated at $\frac{1}{4}$" to $\frac{1}{2}$" scale. Room elevations are also usually at $\frac{1}{4}$" to $\frac{1}{2}$" scale. Wall sections and cabinet work must show more detail and are from $\frac{3}{4}$" to $1\frac{1}{2}$" scale. Certain areas of sections will be further detailed at 3" scale, while moldings and decorative items may even be drawn at half to full scale.

Dimensioning.—While scales should be clearly identified for each drawing either in the title block or beneath each individual layout, contractors should never scale drawings but should insist that the architect furnish them with complete stated dimensions. This is the duty of the architect and the contractor is foolish to take responsibility for it. Blueprints are subject to stretching and shrinking with humidity and some reproductive methods reduce the drawings in size.

Notes on Drawings.—The drawings should not be cluttered with notes which should be in the specifications, but architects' offices will vary in this. The draftsman will often put notes on drawings to alert his own specification writer rather than the contractor. It is the specification that should govern, and all notes on drawings should be checked against the specifications and cross referenced. If a contractor finds discrepancies during bidding, he should report this to the architect and ask for a written statement, known as an Addendum, to clarify it if it would affect his cost.

Schedules.—Schedules may appear either as part of the drawings or the specifications. Room finish schedules are often on the drawings next to the floor plan to which they refer. Schedules for lintels, columns, footings, and doors and frames are usually on the drawings, while hardware schedules are usually in the specifications. Fixture schedules are mechanical and electrical work may be found either place.

Reproduction.—"Blueprints," that is, prints with pencil lines showing in white on a blue background, are still the standard con

ROOM FINISH SCHEDULE

JOB NO. 3224
SHEET NO. 10/7
DATE 6/15/62

ROOM	#	FLOORS: CEMENT	ASPHALT TILE	RUBBER TILE	VINYL ASBESTOS T.	VINYL	LINOLEUM	CERAMIC TILE	WOOD	SLATE	MARBLE	TERRAZZO	SEAMLESS CARPET	BASE AND/OR WAINSCOT: CEMENT HIGH	RUBBER 6" HIGH	VINYL 6" HIGH	WOOD 6" HIGH	CER TILE 6" HIGH	SLATE HIGH	MARBLE 6" HIGH	TERRAZZO HIGH	SEAMLESS HIGH	WALLS: PLASTER	WALLBOARD	CER TILE	CONC BLK	WOOD	CEILING: PLASTER	WALLBOARD	ACOUSTICAL	WOOD	TRIM: WOOD CASING	METAL CASING	WOOD SILLS	METAL SILLS	MARBLE SILLS	PLASTIC SILLS	CHAIR RAIL	CORNICE	BUILT IN CABINET	DECORATING: PAINT FOR FLOORS	PAINT FOR WALLS	PAINT FOR CEILINGS	PAINT FOR TRIM	PAINT FOR DOORS	PAPER FOR WALLS	PAPER FOR CEILINGS	NOTES
Foyer	101										X												X																												
Living Room	102												X				X						X																												
Dining Room	103												X				X						X																												
Kitchen	104						X																X																												
Laundry	105						X																X																												
Powder Room	106								X									X					X																												
Foyer	107	X																					X																												
2nd flr Hall	201												X										X																												
Master Bedrm	202									X							X						X																												
Master Bath	203						X																X																												
Guest Bedrm	204									X							X						X																												
Basement	/		X																				X																												
All Closets																																																			

Finish Same As Room

FRANK B. WALKER CO. PUBLISHERS CHICAGO

struction prints and are required by many building departments for permit in that they are difficult to alter. Notes on them can be added only in colored pencil, either red or yellow. The contractor should limit the notes he makes on his construction set and authorize only one person to add them so that somebody's doodles don't end up in brick and mortar.

Today, many architect's offices are adding their own printing machines. These are usually of the ammonia process which produce black, blue, or maroon lines on a white background. They are much more easily marked on, although the added note will not be as obvious as on a blueprint, unless made in color. Small prints may be run off on one of the many types of office duplicating machines.

If it is desirable to reduce or enlarge a drawing, a photostat, a photographic process that produces negatives as positives, can be used.

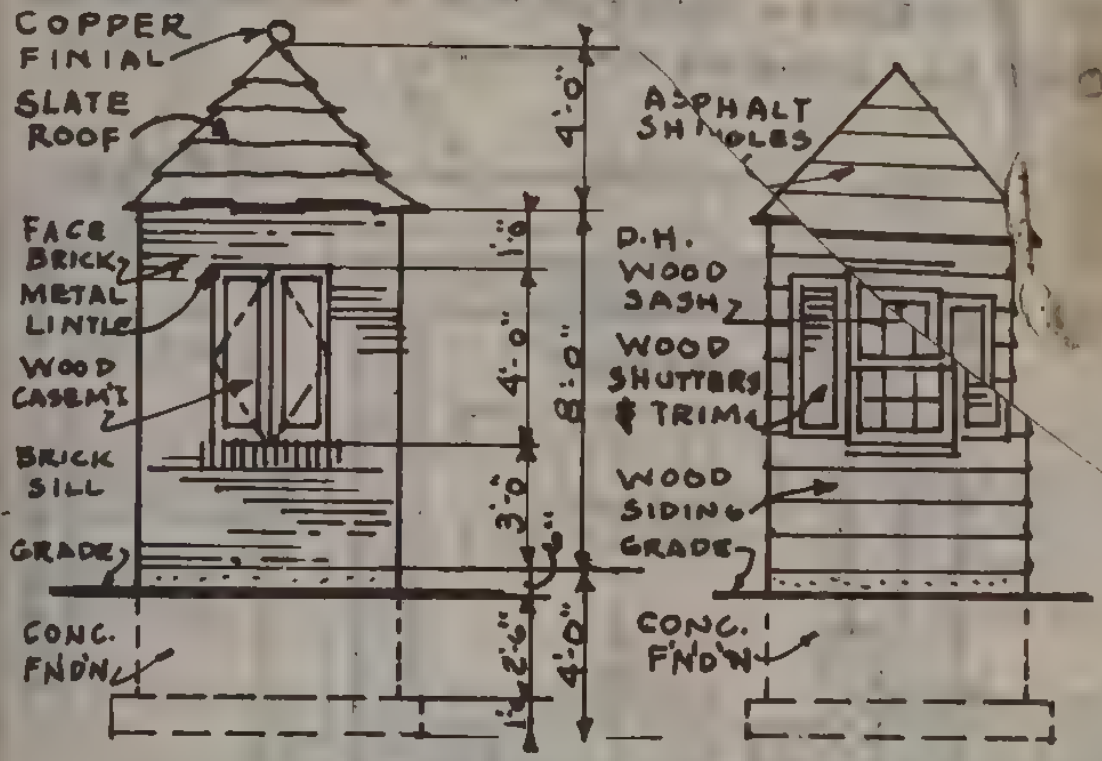
There are processes that transfer blueprints to cloth drawings or to sepia prints, which can be altered, added to and printed just like an original tracing.

Interpreting Lines.—The architect will use various lines in making his drawings. Thick solid lines are used to outline the edges of the plans and elevations. Lines consisting of long and short dashes in sequence denote center lines. Short dashes usually indicate hidden lines, but are also used on windows to show where they are hinged if they are operable. Thin lines are used for dimensions. These terminate in arrows to show the limit of the given dimensions. Repeat marks or the notation "do" indicates the repetition of a given dimension. Dimension lines are often broken by a zigzag which shows the object in the drawing has been shortened.

Symbols.—Material indications, and items relative to plumbing, heating and ventilation, and electrical work have been standardized. Some architects may have a symbol schedule on their drawings, but most no longer do this. The accompanying schedule shows many of the usual symbols a contractor may encounter, but always check with the specifications for building materials as symbols may vary from draftsman to draftsman.

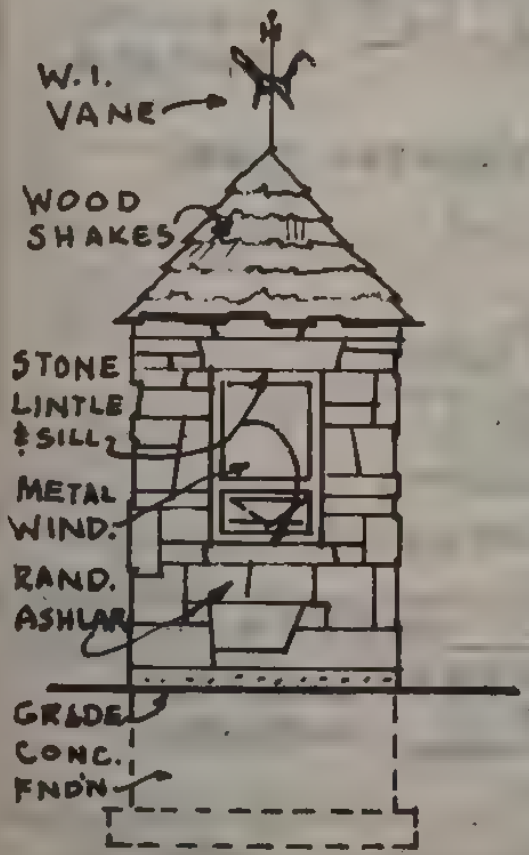
Arrangement.—There has been much restudying of the proper way to set up specifications recently, but little standardization is seen yet among architects.

The most impressive effort thus far is that of the Construction Specification Institute, known as the Uniform System. This system not only sets forth an arrangement for specifications, but is equally applicable to data filing (most of the manufacturers' new

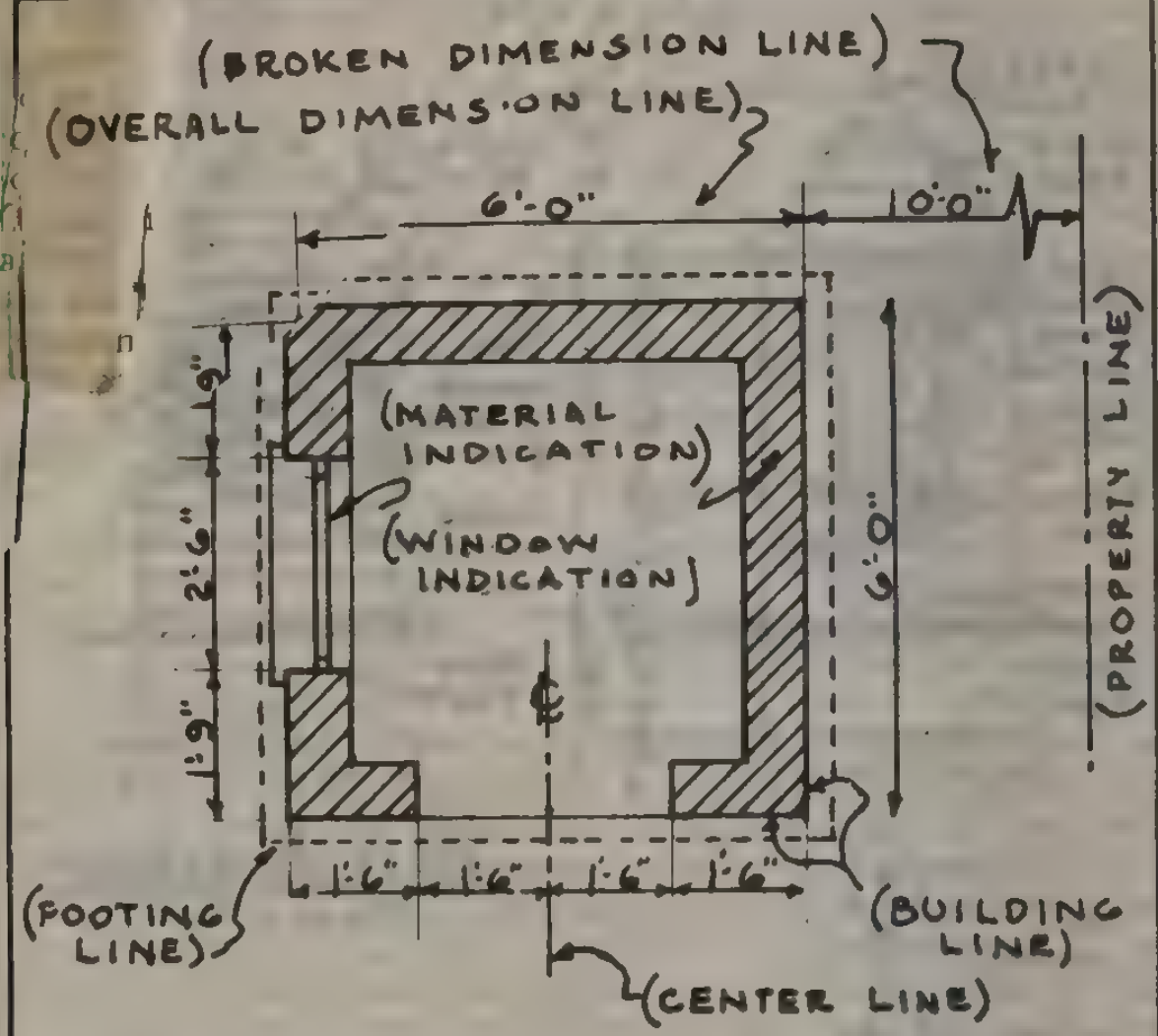


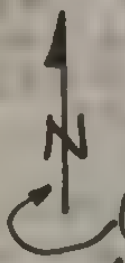
WEST ELEVATION

SCALE: ⅛" = 1'-0"



THE GARDEN SHED SHOWING THE SAME WEST (LEFT SIDE) ELEVATION BUT WITH THREE DIFFERENT MATERIAL INDICATIONS AS MIGHT BE FOUND ON A WORKING DRAWING.





(DIRECTIONAL SIGN)

FLOOR PLAN

SCALE: 1/4"=1'-0"

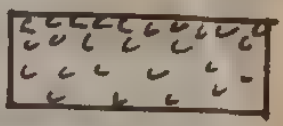
(TITLE BLOCK INFORMATION)

TITLE: FLOOR PLAN OF GARDEN SHED		
REVISION-DATE	PROJECT NAME ADDRESS OWNER'S NAME ADDRESS	ARCHITECT' ADDRESS

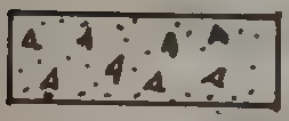
JOB:#____	DATE:____	DRAWN BY:____	SHT#__OF__

EARTH

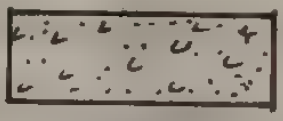
ROCK



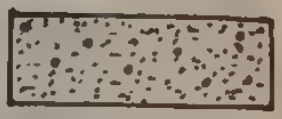
CINDER FILL



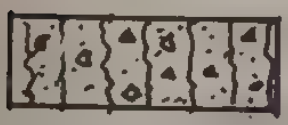
STONE CONCRETE



CINDER CONCRETE



CEMENT



CONCRETE BLOCK

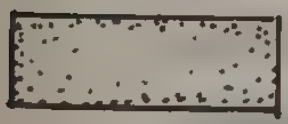
TILE

GYPSUM BLOCK

COMMON BRICK

FACE BRICK

FIRE BRICK



CUT STONE

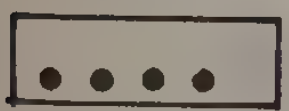
RUBBLE STONE

MARBLE

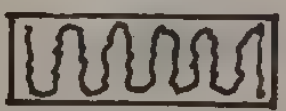
ROUGH WOOD

FINISH WOOD

METAL



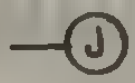
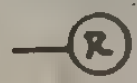
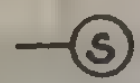
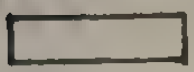
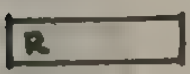
REINFORCING BARS



LOOSE INSULATION

SOLID INSULATION

GENERAL OUTLETS:

CEILING	WALL	
		Fixture Outlet
		Blanked Outlet
		Clock Outlet
		Drop Cord Outlet
		Fan Outlet
		*Junction Box*
		*Recessed Outlet*
		*Pull Switch*
		Exit
		*Surface Fluorescent*
		*Recessed Fluorescent*
		Bare Lamp Fluorescent

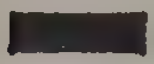
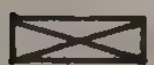
CONVENIENCE OUTLETS:

	Duplex
	Waterproof
	Radio
	Range
	Floor
	Special Purpose

SWITCH OUTLETS:

S	*Single Pole Switch*
S_2	*Double Pole Switch*
S_3	*Three Way Switch*
S_D	*Automatic Door Switch*
S_E	*Electrolier Switch*
S_K	*Key Operated Switch*
S_{CB}	*Circuit Breaker*
S_{MC}	*Momentary Contact*
S_{RC}	*Remote Control*
S_{WP}	*Weatherproof Switch*
S_F	*Fused Switch*

PANELS & CIRCUITS:

	*Lighting Panel*
	Power Panel
	Two Wire Branch Circuit
	Three Wire Branch Circuit
	Under Floor Duct & Box
	Generator
	Motor
	*Controller*

SIGNALLING SYSTEMS:

Push Button

Buzzer

Bell

Chime

Annunciator

Electric Door Opener

Telephone Switchboard

Interconnecting Telephone

Outside Telephone

Fire Alarm Bell

Fire Alarm Station

City Fire Alarm

Automatic Fire Alarm

Watchman's Station

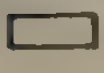
Horn

Nurse's Signal Plug

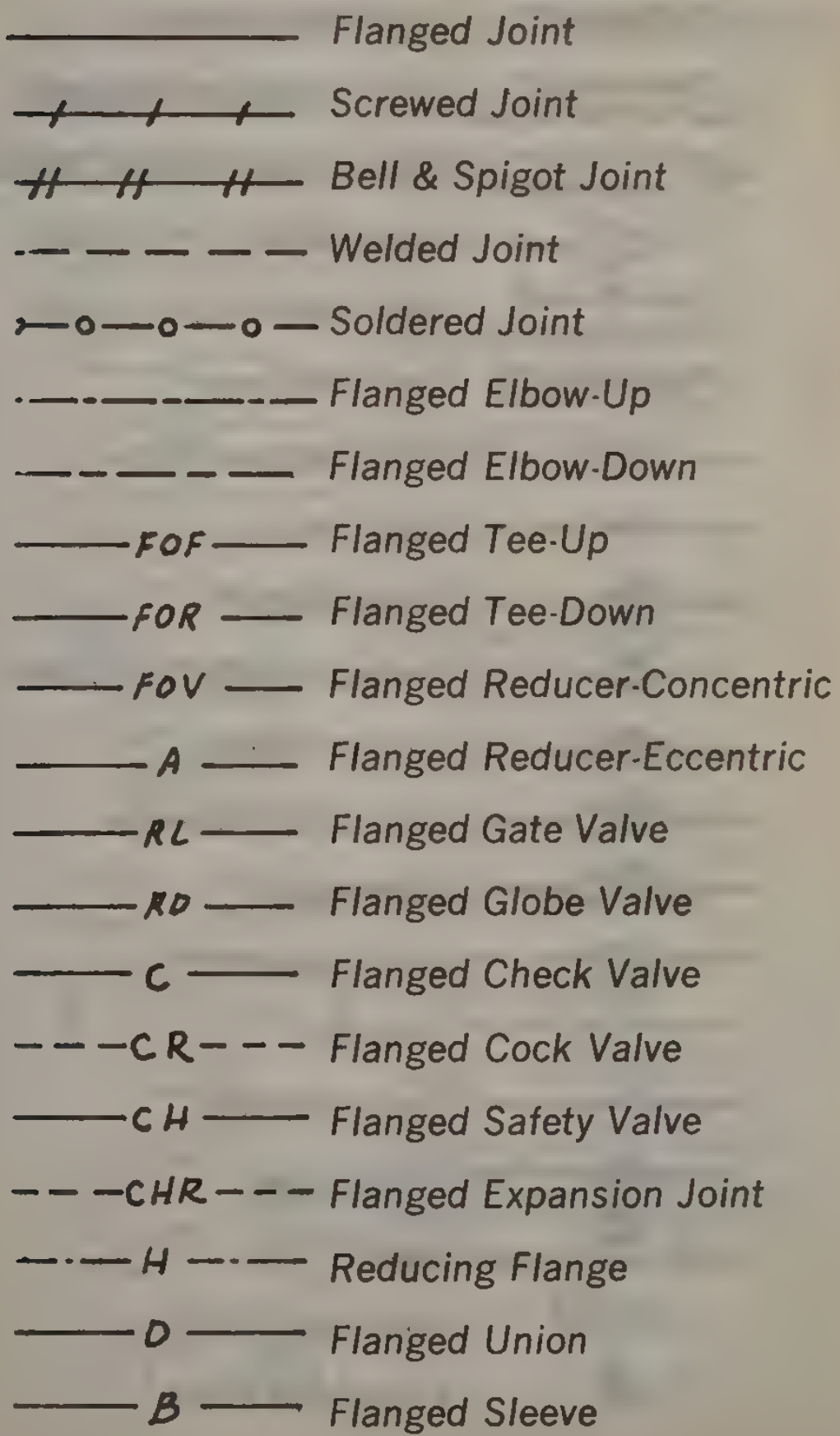
Maid's Signal Plug

Radio Outlet

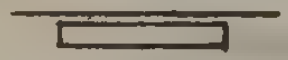
Television Outlet

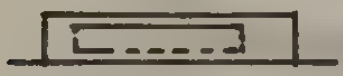

Interconnection Box

PIPE FITTING SYMBOLS:



HEATING SYMBOLS:

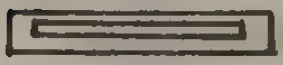

Exposed Radiator


Flush Enclosed Radiator

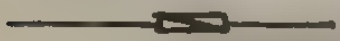
Projecting Enclosed Radiator

Unit Heater (Prop. Fan)

Unit Heater (Cent. Fan)


Unit Ventilator

Thermostatic Trap


Float Trap

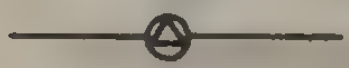
Boiler Return

Pressure Reducing Valve

Air Line Valve

Lock & Shield Valve

Diaphragm


Air Eliminator

Strainer

Thermometer

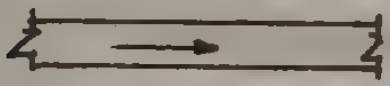
Thermostat

Gage

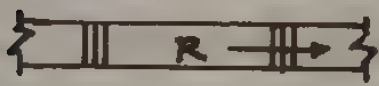
Pressure Switch

Expansion Valve

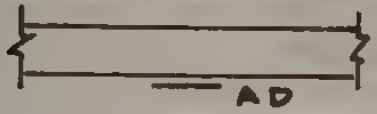
DUCTWORK SYMBOLS:


Duct and Direction of Flow

Inclined Drop

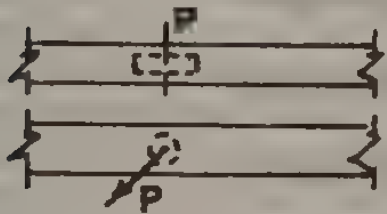


Inclined Rise

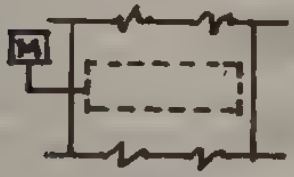


Access Door

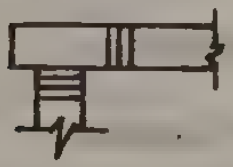
Adjustable Blank Off

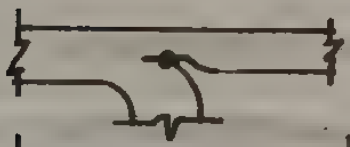


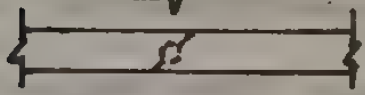
Adjustable Plaque



Automatic Damper


Canvas Connections


Deflecting Damper


Volume Damper

Supply Duct in Section

Exhaust Duct in Section

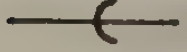
Supply & Exhaust Wall Grilles

Vanes

PIPING SYMBOLS:

Low Pressure Steam

Medium Pressure Steam

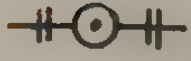

High Pressure Steam

Return Line

Condensate Line

Make Up Water

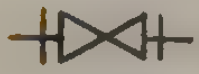
Air Relief Line

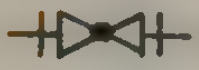

Fuel Oil Flow

Fuel Oil Return

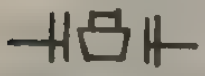
Fuel Oil Vent

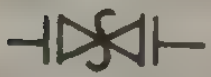
Compressed Air

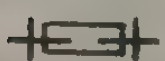

Refrigerant Liquid


Refrigerant Discharge

Condenser Water Flow


Condenser Water Return


Chilled Water


Chilled Water Return

Humidification Line

Drain Line

Brine Supply

catalogs today carry the CSI symbol, a rectangle enclosing three elipses, and the Uniform System number) and to a cost accounting system. The CSI form divides the specifications into four divisions: bidding requirements, contract forms, general conditions, and specifications. The specifications section is divided into 16 categories; a typical specification prior to the CSI format might run to 60 sections. The present suggested divisions under the fourth division, "Specifications," are as follows:

Division 1. General Requirements, including summary of work, schedules and reports, samples and shop drawings, temporary facilities, cleaning up, project closeout, allowances and alternates.

Division 2. Site Work, including clearing of site, earthwork, piling, caissons, shoring and bracing, site drainage, site utilities, roads and walks, site improvements, lawns and planting, railroad work, and marine facilities.

Division 3. Concrete, including formwork, reinforcement, cast-in-place concrete, precast concrete, and cementitious decks.

Division 4. Masonry, including unit masonry, stone and masonry restoration.

Division 5. Metals, including structural, joists, decking, light-gage framing, miscellaneous metals, ornamental metals and special formed metals.

Division 6. Carpentry, including rough, finish, glue laminated and custom woodwork.

Division 7. Moisture Control, including waterproofing, dampproofing, insulation, shingles and roof tiles, preformed roofing and siding, membrane roofing, sheet metal work, wall flashing, roof accessories, and caulking and sealants.

Division 8. Doors, Windows and Glass, including metal doors and frames, wood doors, special doors, metal windows, wood windows, finish hardware, operators, weatherstripping, glass and glazing, curtain walls, and store fronts.

Division 9. Finishes, including lath and plaster, gypsum, tile, terrazzo, veneer stone, acoustics, wood flooring, resilient flooring, special flooring, special coatings, painting and wall coverings.

Division 10. Specialties, including chalk and tack boards, chutes, compartments and cubicles, demountable partitions, disappearing stairs, firefighting devices, fireplace equipment, flagpoles, folding gates, identifying devices, lockers, mesh partitions, postal specialties, retractable partitions, scales, storage shelving, sun control devices, telephone booths, toilet and bath accessories, vending machines, wardrobe specialties, and waste disposal units.

Division 11. Equipment, including that for banks, commerce,

darkrooms, churches, education, food service, gymnasiums, industry, laboratories, laundries, libraries, medicine, mortuaries, parking, prisons, residences, and stage.

Division 12. Furnishings, including artwork, light control, cabinets, carpets, drapes, furniture, and seating.

Division 13. Special Construction, including audio, bowling, broadcasting, cleaning, conservatory, incinerator, integrated ceiling, observatory, pedestal floor, prefabricated, chimney, vault, swimming pool and zoo.

Division 14. Conveying Systems, including elevators, dumbwaiters, hoists and cranes, lifts, material handling, escalators and tubes.

Division 15. Mechanical. Divided into general provisions, basic materials and methods, and plumbing, heating, ventilating and cooling covering water supply, soil and waste, roof drainage, plumbing fixtures, gas piping, special piping, fire extinguishing, fuel handling, steam, hot water, chilled water, dual temperature air tempering, refrigeration, and controls and instruments.

Division 16. Electrical, including general provisions, basic materials and methods, electrical service, distribution, fixtures, communication, TV, power, heating, controls and lightning protection.

As stated previously, few specifications in just this form will be found today, but the Uniform System has both industry and professional support and should be encouraged. It is certainly to the advantage of the contractor to have specifications in the same form from job to job.

Subdivision.—Each section of the specification division will be subdivided into the "Scope," or "Work Included;" "Materials," listing the quality of all materials to be furnished; and finally, "Fabrication and Erection," defining the quality of workmanship desired.

"Scope" will include those items to be furnished and installed, those items to be furnished but installed by others, those items furnished by others and installed under this division, and finally, related work in other divisions of the specifications. "Scope" will also list some general requirements such as those for shop drawings, samples, tests, methods of delivery and storage and the like that may be required. However detailed, the "Scope" section will not include each and every item. The drawings must always be checked against "Scope" which often carries the phrase "including, but not limited to, the following."

"Materials" will list the materials to be used in one of several ways, often found in combination. The "closed specification" will

list a single trade name and this must be furnished. The "contractor's option specification" (or "bidder's choice") will list more than one trade name and the contractor may choose which of those listed he prefers to use. The "substitute bid specification" may list a choice of trade names and the bid must be based on one of the products included, but the contractor is allowed to suggest a substitute at the time of submitting his bid, naming the amount he would subtract for using the alternate product.

A variation of this is the "product approval specification" which asks the contractor to submit any substitutions prior to submitting his bid. If the architect approves the substitute, it will be put in an addenda sent to all contractors. The "or approved equal" type specification which names a product but qualifies it by "or approved equal" is the most common type in general practice and provides the widest competition and rewards to the contractor who knows his products, prices and sources.

However, it is the architect who rules whether the product is "equal." If the contractor questions its approval, he should bring his substitute to the architect's attention upon being selected as the low bidder so any adjustments can be made should the architect rule his substitution is not equal before award of contract.

The "product description specification" is used to describe bulk materials and some manufacturers' articles, the latter particularly in government work. The "performance specification" describes not the material, but what job it is required to do, either in matters of strength, mechanical ability, or similar measurable result. Specifications based on "reference standards" refer to specifications published by national organizations related to the building industry. These are often encountered. The more commonly referred standards are:

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASHVE	American Society of Heating and Ventilating Engineers
ASTM	American Society for Testing Materials
AWI	Architectural Woodwork Institute
AWS	American Welding Society
BSI	Building Stone Institute
CS	Commercial Standards (U.S. Dept. of Commerce)
CSI	Construction Specification Institute

IES	Illuminating Engineering Society
ILI	Indiana Limestone Institute
MIA	Marble Institute of America
MLMA	Metal Lath Manufacturers Association
NBFU	National Board of Fire Underwriters
NFPA	National Fire Protection Association
NLMA	National Lumber Manufacturers Association
NTMA	National Terrazzo and Mosaic Association
PC	Producers Council, Inc.
PCA	Portland Cement Association
SPA	Southern Pine Association
SJI	Steel Joist Institute
SCPI	Structural Clay Products Institute
TMA	Tile Manufacturers Association
UL	Underwriters' Laboratories

These specifications are general in nature and usually apply only in part to the specific job. A contractor should build up a library of these publications to check specification references to them. They are informative and worthwhile.

In addition, many architects will refer to the published specifications of a named manufacturer. These are easily available and generally are included in regards to installation procedures.

"Fabrication and Erection" will set performance standards for both shop and field work and will include, if required, sections on protection, cleaning, guarantees, warranties, maintenance and operating instructions. The specifications of trade organizations and manufacturers' installation instructions are often made a part of this section.

"Alternates." The architect often may wish to investigate at the time of bidding the cost, either upward or downward, of a substitute product, material or procedure, or adding or subtracting work from the contract. Such requests for alternate prices are usually noted at the end of the section of the specifications to which they refer, and are repeated at the end of Division 1 of the specifications and on the proposal form. On the typical Lump Sum proposal form, the Alternate follows the statement of the Lump Sum price in such form as:

If the following Alternates are accepted,	Add:	Deduct:
Alternate No. 1	$_____	$_____
Alternate No. 2	$_____	$_____

Obviously a request for a lot of Alternates complicates bidding and sometimes the extent of the Alternate is not clear. Since the architect will accept the price change for an Alternate with the

same responsibility as attached to the Lump Sum figure, the contractor must be certain of all the possible contingencies involved should the change be accepted.

Often an Alternate is put under only the one section that makes the basic substitution, but other subcontractors' work is also affected by the change. It is the contractor's responsibility to foresee this. As an example, under Carpentry, an architect might include:

"Alternate No. 1—For substituting one 3'-0"x6'-8"x1¾" door with frame for the two 3'-0"x6'-8"x1¾" doors and frame shown between the living and dining rooms, deduct $_____."

Obviously, the door cost will be less but the wall construction will be more, and no mention may occur under that division.

"Cash Allowances." Sometimes, the architect may not have a final decision from an owner on certain items and, rather than leave them out of the Lump Sum proposal, he gives a definite budget amount in the specification that is to be included in the bid. This is often encountered with the selection of brick and hardware and other finish items. As an example:

"Facing brick shall be included under an allowance of $75 per M, fob, job site."

Thus, every bidder will include the same material cost, rather than guessing just what the "face brick" the owner may choose will cost. Most always, cash allowances are for the cost of material and applicable taxes delivered to the site only. Labor to set, overhead and profit on the material should be included in the Lump Sum price unless specifically noted otherwise.

Upon completion of the job, the actual cost of the items furnished under the Allowance shall be tabulated with any savings credited to the owner, any overruns added to the contract cost.

"Unit Prices." Where quantity of materials is in doubt, but quality is know, the specification may ask for Unit Prices. As opposed to Allowances, Unit Prices are set by the bidder, not the architect; they are firm and binding on the bidder, the Lump Sum price being adjusted up or down due only to variation in the quantity actually used on the job.

Unit Prices are included on the proposal form for each material per unit of measure. Unit Prices are often asked for concrete per sq. yd., piling per lineal ft., partition block per sq. ft., etc. These prices should be complete with all costs, profit and overhead included.

Unit Prices must be quoted with care, even though the amount of work covered by them is small, as they will be compared di-

rectly with those submitted by other bidders and the owner may expect the same Unit Prices to hold on additional work.

"Addenda." Few plans and specifications are perfect when they leave the architect's office and the contractors bidding the job should call to the architect's attention all discrepancies they note. These, plus changes the architect and owner may wish to make after the plans and specifications have been issued, but before bids are turned in, are incorporated in the Addenda. This usually takes the form of a printed sheet or sheets the same size as the specification to which it should be attached. Addenda eventually becomes a part of the Contract Documents.

Often, even changes to the drawings can be described and included this way. But sometimes additional drawings or sketches must be issued, or a drawing is reissued with a revision date. Reissued drawings, however, usually should be avoided during bidding.

Each Addendum is given a number and the changes it covers will be listed in the order the divisions occur in the specification, with drawing changes last.

Sometimes, Addenda must be acknowledged by signing a receipt; sometimes they are sent registered mail, but usually they are acknowledged on the proposal form in a space provided for it. The single Addendum or several Addenda are also included in the Owner-Contractor Agreement.

Upon receipt of an Addendum, the contractor should mark his specifications and drawings with appropriate notes, or with a stamp on each affected page saying "See Addendum #_____." The Addendum will usually identify the change by division and page number and a reference to location on the page. As an example:

3:01—**Scope**: Add item "h) Remove existing wire fence along north edge of property."

6:02—**Materials**: Delete paragraph referring to concrete masonry lintels and add ". . . lintels in block work shall be units of sizes and shapes shown on the lintel schedule."

Dwg. Sheet A-2: Move rolling shutter door from center of Bay C-D to just north of Column B.

Dwg. Sheet A-4: Delete ladder to roof.

"Change Orders." Change orders are Addenda issued after the contract is signed. Errors on drawings and specifications are usually uncovered during bidding. A contractor who sees where a drawing is not complete and therefore does not include what he knows must be furnished in his price, is not only playing danger-

ously with his reputation, but may very well end up having to pay for the item anyway to complete the job or face a lengthy law suit.

However, some Change Orders are necessary due to job conditions, changes required when plans are submitted for permits, substitutions made to satisfy the owner or his mortgage holder, products not being available, or because, as the job progresses, certain changes for the benefit of the job become obvious.

The contractor must cooperate in making these changes. This is set forth in Article 12 of the General Conditions. Sometimes no cost is involved. Most often, an extra is called for. This may be handled by a firm price change being submitted, or an order to proceed on a time and material basis. The Change Order is issued by the architect but signed by the owner and contractor. The format of the change order will follow closely that of the Addendum, except that costs of changes and tabulation of the new contract amount are added. The Frank R. Walker Company publishes a standard form, L-101, in triplicate, for contract change orders, a sample of which is shown on page 36.

SUMMARY

As can be imagined, practices as to what appears on drawings and what is stated in specifications will vary from job to job. There is no legal precedent that one is more binding than the other, although some specifications will state which is to be followed in case of duplication.

In general, sizes, quantities, design and location will be best taken from the drawings. Materials, quality, procedures and general requirements are most reliably defined in the specifications. Never rely solely on one or the other. A draftsman's delineation of a stone wall in elevation may not show at all the coursing called for in the specifications, while the specifier may make no special mention of a stone sill condition carefully detailed on the drawings. One must always complement the other.

CONTRACT CHANGE ORDER

JOB Smith Store Building
CONTRACT JOB NO. 527

CHANGE ORDER No. 1

FOR

DATE July 7, 19--

TO Andrews Construction Company
209 E. Elm Street
Arlington, Illinois

REVISED CONTRACT AMOUNT

PREVIOUS CONTRACT AMOUNT $23,112.00

AMOUNT OF THIS ORDER $ 411.00

TOTAL CONTRACT AND EXTRAS $23,523.00

To cover paving of 25'-0" x 25'-0" area at rear of Smith Store Building site at 656 N. Main St., Arlington, Illinois, as stated in Extra Work Order No. 1, dated July 5, 19--, and as follows:

Elevation of concrete slab to be same as sidewalk.
Concrete slab to be placed on a well tamped bed of cinders, 4 inches thick after tamping.
Concrete slab to be 5 inches thick and to have a monolithic trowel finish.
Concrete to be same mix as for sidewalk (2500 lb. ready-mix).

The work covered by this order shall be performed under the same Terms and Conditions as that included in the Original Contract

CHANGES APPROVED

_____

By _____

_____

By _____

AMOUNT OF ORIGINAL CONTRACT $23,112.00

CHANGE NO. 1 411.00

Johnson and Anderson, Architects

By _____

Form L 101

CHAPTER III

SETTING UP THE ESTIMATE

Estimating is one of the most important aspects of a building contractor's business. In nearly every instance it is necessary for a contractor either to estimate the cost of the work, or to bid in competition with others before a contract for the work is awarded. If a contractor's bid is too low and a contract is awarded on the basis of it, the contractor often must complete the work without profit and sometimes at an actual loss in both time and money.

A contractor must know his limitations and those of his organization as to the size, complexity, and quality of work that he can efficiently handle. To exceed these limitations often leads to a poor contract which can be costly not only monetarily, but also in making dissatisfied customers and loss of future opportunities for bidding.

Most contractors fall into categories as to the type of work which their organizations can handle efficiently, expeditiously, and profitably. A heavy construction contractor specializing in structures such as airport runways, highways, bridge abutments, etc., usually should forego bidding on such work as churches, banks, hospitals or modern office buildings. A contractor whose organization and personnel are geared to a particular category of construction can find himself in difficulty if he strays from his specialty.

Many contractors in business today are former employees of contracting firms who have broken away from them to go into business for themselves. Many of these people doubtless were exceptional mechanics, foremen or superintendents, and had a thorough understanding of how the work should be carried out in the field, but lack business ability and training to estimate costs accurately. Some of these contractors make a reasonable profit on their work and remain in business, but many more of them fail and eventually go back to working for someone else.

There are various reasons for these failures, but probably the most important one is the inability of the person estimating costs to come up with realistic and profitable estimates. The procedures involved in preparing an accurate, detailed cost estimate necessary for a realistic bid are relatively simple and most contractors

know them well. Yet almost all instances of failure of contracting firms are the result of poor estimating practices, and the consequent submission of unsound and unprofitable bids. There is no substitute for complete and detailed material take-offs and pricing in preparing a bid, and in cross-checking estimated costs with actual costs so that adjustments in pricing can be made for future bidding.

Another common reason for failures in the contracting business is overexpansion. Again, the contractor must know the capabilities of his office and supervisory staff and how much they can adequately handle at any one time. The successful contractor does not take on more work than his staff can take care of efficiently.

Bonding and insurance companies have certain minimum requirements which must be met by contractors applying for surety bonds or contractual liability insurance. Some of the most important considerations which such companies investigate before they will bond an applicant are as follows:

1. The technical ability of the contractor applying for a bond, whether or not he understands his business thoroughly, and his capabilities in the preparation of detailed cost estimates.
2. The reputation of the contractor for honesty and his standing among those with whom he does business.
3. The financial ability of the contractor, and whether or not he has sufficient capital at his disposal to carry on his business, purchase materials and supplies, meet his payrolls and current expenses, etc.

Bonding companies seldom get the opportunity of bonding the best contracting firms. On public work projects the bidding is usually open to all bidders and in some instances as many as fifty or more bids may be received on one job. In most cases, the lowest bidder is awarded the contract, and he often may be the poorest risk because of substandard estimating procedures, lack of technical ability to perform the work as specified, and lack of financial ability.

On privately owned projects, the risk to the bonding company may not be as great as it is on public work as the bidding list can be controlled and only contractors with the proper credentials may be asked to submit proposals. Architectural and engineering firms which handle work for private owners are often asked to select contractors to bid on a project. They will attempt to choose bidders whom they know can perform the work equally well and will carry out the intent of the drawings and specifications in the best interest of the owner.

The above illustrates the fact that somebody besides the con-

tractor attaches importance to a correct and detailed estimate. A well prepared estimate has just as much to do with the success of a contractor as the manner in which he purchases his materials, lets his subcontracts or carries out his work on the job.

What Is the Correct Method of Preparing an Estimate?

If twenty estimators or contractors were furnished the same set of plans and specifications and told to prepare an estimate of cost from same so that the different methods might be compared, it is safe to assume there would be not more than two estimates in the entire twenty that had been prepared on the same basis or from the same units.

This is wrong. Why should there be such a variation in methods with only one result to be obtained? It is due to the absence of a uniform method of estimating; the lack of detailed information regarding the cost of the work to be performed with the result that each contractor has developed a system of his own, making it almost impossible for one contractor to check another's figures. This often results in the successful bidder being so ridiculously low that if awarded the contract he will be compelled to complete it at a loss or so unreasonably high as to be completely out of the running.

When measuring the plans and listing the quantities on the estimate sheet preparatory to pricing and making up the estimate, it is important the quantities of the different classes of work should be estimated so far as practical in the same manner in which the work will be constructed on the job. It is only by observing and learning the costs of the various operations on the job that the estimates will prove dependable.

As previously mentioned, the practice of lumping an estimate is not only a serious mistake but sooner or later it will cause the user a substantial loss, perhaps one that will put him out of business entirely. In more than one instance a life's work has been ruined to save an hour or two in the preparation of an estimate.

The Value of Detailed Estimates

The author has never found any of the so-called short cuts in estimating accurate enough to use in competitive bidding. They are all right when preparing preliminary estimates or approximate figures, but when submitting a proposal on a job that you are anxious to obtain—at a profit—take a little extra time and figure the work in as much detail as is necessary to

PRACTICAL PUBLISHING CO. Form 116

GENERAL ESTIMATE

BUILDING F.T. Jones Residence
LOCATION Arlington, Illinois
ARCHITECTS Wilson & Davis
SUBJECT General

ESTIMATE NO. 218
SHEET NO. 1
ESTIMATOR E.F.I.
CHECKER J.M.B.
DATE Sept 15, --

DESCRIPTION OF WORK	NO PIECES	DIMENSIONS L	W	D	FIGURED & BILLED EXTENSIONS	PUBLISHED, CATALOGUE EXTENSIONS	TOTAL ESTIMATED QUANTITY	UNIT	TOTAL ESTIMATED MATERIAL COST	UNIT	TOTAL ESTIMATED LABOR COST
Earthwork											
Strip top soil		86 0	38-0	0 6	1634 cf		61	cy	100	61	
General excavation		80 0	32-0	6 0	15360 cf		569	cy	100	569	
Hand exc for ftgs		205·4	1-4	0-8	183 cf		9	cy			3 25	29
	5	2 0	2-0	0 10	17							
		8-8	3 8	0-10	26	226 cf						
Interior grading		74-8	26-8		1991		1991	sf			3	60
Exterior grading		248·0	10-0		2480		2480	sf	2	50		
Foundation Concrete – 2500-lb Ready-Mix												
Footings		205 4	1 4	0-8	183 cf		9	cy	13 00	117	2 50	23
	5	2 0	2-0	0-10	17							
		8-8	3-8	0 0	26	226 cf						
					Concrete	Forms						
Foundation walls	25	205 4	0 8	7-8	1049	3148	39	cy	13 00	507	2 75	107
							3148	sf	8	252	15	472
Basement Floor – 4" pea gravel, 4" concrete, monolithic trowel finish												
		74 8	26-8		1991		1991	sf	23	458	15	299
Masonry												
Lightweight concrete block – 8 x 8 x 16												
		19 4	x	8-8	1683	sf x 1 1/2	1892	pcs	26	492	30	567
Face brick		19.4	x	12 8	2485	sf x 7	17 1/2	M	80 00	1400	100 00	1750
Common brick		20 4	x	12 8	2558	sf x 7	17 1/2	M	38 00	665	75 00	1312
Additional material and labor for fireplace							1 lot			75		100
Flue lining – 8" dia							20	l f	50	10	30	6
13" x 13							10	l f	50	15	40	4
Chimney Cap – 8 0 x 3 0 0 4 – Limestone							1	lot		75		25
						Ad-vard				2660		1497

Correct Method of Listing Quantities on Estimate Sheets

provide accurate and dependable quantities and costs.

As an example of this practice, take a section of wood floor for an ordinary building, consisting of wood joists, bridging, subflooring, deadening felt or building paper, wood furring strips or screeds and the finish flooring. Many contractors will price this work at a certain price per sq. ft. of floor, including all of the above items.

To construct this floor requires six different materials and labor operations. First, the wood joists must be cut to length and placed in position; the bridging placed between the joists; the subflooring or sheathing placed; and when the finishing of the building is under way, the deadening felt or building paper is laid, the furring strips placed and then the finish flooring is laid and sanded.

Each of the above requires a distinct labor operation and should be estimated as such because in this way it is possible to compare actual and estimated costs on each class of work. This enables the contractor to tell where the money is being made or lost and may prevent similar mistakes on future work.

Short cuts in estimating have probably cost contractors more money than they ever made from them. With keen competition, an error of a few per cent may cost the successful bidder his profit on a job.

What Are the Qualifications of a Good Estimator?

The estimator is the most important man in any contractor's organization because it is up to him to prepare estimates that will either make or break the contractor. The most efficient job organization or the best purchasing department in existence can not make money on contracts taken below cost.

On the other hand, it does not take a good salesman or contact man to obtain all the work you can handle if your estimates are way below your competitor's. Remember, the low man is wrong more often than he is right,—so the efficient organization is one that can get the work at the right price. It is not an easy task, but a business built upon the principles of service, dependability, good materials and workmanship, and fair price, will be in business many years after the get-the-work-at-any-price contractor has made his last assignment in favor of his creditors.

The estimator should be a practical man. He should possess a thorough understanding of job conditions; how the work will be carried on in the field, and the operations necessary to assemble the materials and put them in place in the structure. He

Form 114

GENERAL ESTIMATE

BUILDING F. T. Jones Residence — ESTIMATE No. 218
LOCATION Arlington, Illinois — SHEET No. 2
ARCHITECTS Wilson & Davis — ESTIMATOR E.F.Z.
SUBJECT General — CHECKED J.M.B.
DATE Sept 15, --

DESCRIPTION OF WORK	NO PIECES	DIMENSIONS			FEET & INCHES OR EXTENSIONS	PUBLISHED, CATALOG EXTENSIONS	TOTAL ESTIMATED QUANTITY	UNIT OF MEASURE	UNIT COST OF MATERIAL	TOTAL ESTIMATED MATERIAL COST	UNIT COST OF LABOR	TOTAL ESTIMATED LABOR COST
Rough Carpentry					Brought Forward					2440		1497
2x6 Wall plates, bolted to conc. fdtn. wall							208	LF	14	29	22	46
Bolts set in wall top, ½" dia. x 8"							90	Pcs	10	9	5	5
1st floor joists	128	2	x 10	14-0	2987	SF	3347	BF	14	469	5½	184
	18	2	x 10	12-0	360							
					3347	BF						
1x3 Bridging							114	Sets	10	11	25	29
5/8" Plywood sub-flooring							2728	SF	22	600	8	109
		76-0	28-0		2128	SF						
Add for double thick		14-0	12-0		168							
" " "		24-0	18-0		432							
					2728	SF						
25/32" x 2¼" Oak flooring												
		52-0	28-0		1456	SF						
Less		14-0	12-0		68							
					1288	SF x 1⅓	1717	BF	30	515	10	172
Exterior wall framing							1307	BF	14	183	8	105
All plates	52	2	x 4	12-0	416	BF						
studs	194	2	x 4	8-0	507							
Lintels	16	2	x 12	12-0	384							
					1307	BF						
25/32" Vapor seal sheathing							1664	SF	12	200	1½	75
		208-0	x	8-0	1664	SF						
1 x 10 Beveled siding - Redwood												
		208-0	x	8-0	1664	SF Gross						
Window Outs	2	6-0	x	2-0			24					
" "	7	4-0	x	2-0			56					
" "	6	4-0	x	4-0			96					
Door "	2	3-0	x	7-0			42					
					1664		218					
	Less Outs				218							
					1446	SF x 1.19	1721	BF	25	430	7	120
						Forward				1906		5948

Correct Method of Listing Quantities on Estimate Sheets.

must be able to visualize. He must be able to take a set of blueprints and draw a mental picture of the building during construction. He must know every branch of the work to be handled; the materials required, and the labor operations necessary to convert a pile of gravel, sand, brick, cement, lumber, steel, glass, etc. into a completed building.

On the other hand not every visualizer can be a successful estimator. Your job superintendent or foreman may be able to take a set of blueprints and lay the entire job out in his mind and picture the building progressing from the foundation to the finished structure, but unless he possesses the knowledge necessary to compute the quantity of materials and the labor cost of putting them in place, he will never be able to prepare an accurate estimate of cost.

The following seven requisites are essential for the making of a good estimator:

First: He should be able to read plans and measure them accurately.

Second: He should possess a fair knowledge of arithmetic, including addition, subtraction, multiplication, division, together with a knowledge of the decimal system. Nearly all measurements and computations in the average building estimate are made in lineal feet, square feet or yards, and cubic feet or yards. These material quantities are then usually multiplied at a certain unit price, so a knowledge of decimals is necessary to obtain the various costs.

Third: He should be able to visualize,—that is, he should be able to take a set of blue prints and draw a mental picture of the building; how it will look during construction and at completion. He must be able to place his equipment so that the work can be handled economically. In short, he must first construct the building on paper.

Fourth: He should possess an intimate knowledge of job conditions, the most practical methods of handling materials and labor on the job and the most economical methods of construction. While the estimator is generally an office man, he must possess much the same knowledge of construction methods as your superintendent or foreman.

Fifth: The knowledge and ability to assemble materials into workable units. A thousand brick in the wall means more than just the brick. It means a certain amount of sand, lime and cement, and possibly mortar color, to make the mortar. A cubic yard of concrete means the exact quantities of cement,

sand and gravel must be computed. The same applies to nearly every complete unit in the building. The competent estimator must have this knowledge at his finger tips.

Sixth: He should possess an intimate knowledge of labor performances and operations and be able to convert them into costs in dollars and cents. This requires a working knowledge of what a man will do under given conditions and is obtained only by a careful study of different jobs completed under varying conditions.

Seventh: He should be endowed with at least an average amount of common sense.

Listing the Quantities On the Estimate

When measuring the plans and listing the quantities on the Estimate Sheet, all quantities should be listed in the same manner and the same units of measure in which the work will be constructed on the job. The job costs should be reported in the same units as the work is estimated. This is essential if the job costs are to be of value to the estimator in preparing future estimates on similar work.

Material and labor costs should be estimated separately, because there is usually more variation in labor costs than in material costs.

The illustrations are intended to show how the various items should be listed on the estimate sheet. After all measurements have been taken from the plans, the quantities are extended and reduced to workable units.

OFFICE OVERHEAD EXPENSE

The item of adequate overhead expense is sometimes neglected by many contractors, but it is of such importance that every contractor should give it careful consideration.

Every contractor has a certain fixed expense that must be paid regardless of the amount of work done or contracts received, and these items should be charged to Overhead Expense.

This includes such items as office rent, fuel, lights, telephone and telegraph, stationery, office supplies, advertising, trade journals and magazines, donations, legal expenses not directly chargeable to any one job, fire and liability insurance for the office, club and association dues, office employees, such as bookkeeper, stenographer, clerks, estimator, and salaries of executives.

PRACTICAL

SUMMARY OF ESTIMATE

Form 110

BUILDING Central College Admin Bldg LOCATION Chicago, Ill. ESTIMATE NO. 907

ARCHITECT Smith & Williams OWNER Central College DATE Sept. 30

CUBICAL CONTENTS 328,900 Cu. Ft. NO. OF STORIES 3 COST PER CUBIC FOOT $1.67 ESTIMATOR E.F.Z.

FLOOR AREA, SQUARE FEET 35,780 Sq. Ft. COST PER SQUARE FOOT $14.35 CHECKER J.M.B.

CLASSIFICATION	TOTAL ESTIMATED MATERIAL COST	TOTAL ESTIMATED LABOR COST	TOTAL SUB-TOTAL	TOTAL	ADJUSTMENTS
1. GENERAL CONDITIONS AND OVERHEAD EXPENSE	2515 -	8015 -		10530 -	
2. PERMITS, INSURANCE, BONDS AND TAXES	1800 -			1800 -	
3. CONSTRUCTION PLANT, TOOLS AND EQUIPMENT	4220 -	2710 -		6930 -	
4. WRECKING AND CLEARING SITE	250 -	1250 -		1500 -	
5. EXCAVATING AND PUMPING	4040 -	2160 -		6200 -	
6. SHORING AND UNDERPINNING	-	-	-	-	
7. PILING OR CAISSONS	-	-	-	-	
8. FOUNDATIONS AND RETAINING WALLS	5722 -	4535 -		10257 -	
9. WATER AND DAMPPROOFING	-	-	669 -	669 -	
10. CEMENT FLOORS, WALKS AND PAVEMENTS	4190 -	3429 -		7619 -	
11. BRICK, TILE AND CONCRETE MASONRY	8602 -	12903 -		21505 -	
12. CAST STONE, CUT STONE OR GRANITE	15650 -	6706 -		22356 -	
13. TERRA COTTA	-	-	-	-	
14. ARCHITECTURAL CONCRETE	-	-	-	-	
15. REINFORCED CONCRETE	29442 -	35984 -		65426 -	
16. TILE, GYPSUM OR CONCRETE BLOCK FIRE-PROOFING	3263 -	6927 -		10190 -	
17. ROUGH CARPENTRY	11247 -	7223 -		18470 -	
18. FINISH CARPENTRY	15853 -	7926 -		23779 -	
19. WOOD FLOORS	-	-	-	-	
20. INSULATION, SOUND DEADENING, ACOUSTICAL TILE			17200 -	17200 -	
21. WEATHER STRIPS AND CAULKING			2360 -	2360 -	
22. LATHING AND PLASTERING			23400 -	23400 -	
23. FIRE DOORS AND WINDOWS			4800 -	4800 -	
24. HOLLOW METAL DOORS AND TRIM			-	-	
25. STEEL SASH, DOORS, PARTITIONS, SKYLIGHTS			-	-	
26. SHEET METAL WORK, SKYLIGHTS, FLASHINGS, ETC			1650 -	1650 -	
27. ROOFING, BUILT-UP, TILE, SLATE, METAL			1690 -	1690 -	
28. TILE AND MOSAIC FLOORS, WALLS, STAIRS			3790 -	3790 -	
29. ASPHALT, CORK, LINOLEUM AND RUBBER TILE			2750 -	2750 -	
30. ART MARBLE AND SCAGLIOLA			-	-	
31 MARBLE AND SLATE			4220 -	4220 -	
32. GLASS AND GLAZING, STRUCTURAL GLASS			8110 -	8110 -	
33 PAINTING AND DECORATING			5780 -	5780 -	
34 STRUCTURAL IRON AND STEEL			14500 -	14500 -	
35. MISCELLANEOUS IRON AND STEEL			2060 -	2060 -	
36. ORNAMENTAL IRON, ALUMINUM, BRONZE, STEEL	-	-	2750 -	2750 -	
37 ROUGH HARDWARE	2058 -		-	2058 -	
38. FINISH HARDWARE	5600 -		-	5600 -	
39. PLUMBING, SEWERAGE AND GAS-FITTING	-	-	18200 -	18200 -	
40. VACUUM CLEANING SYSTEM			-	-	
41. HEATING AND VENTILATING			55000 -	55000 -	
42 AIR CONDITIONING			-	-	
43 POWER PLANT EQUIPMENT			9410 -	9410 -	
44 ELECTRIC AND POWER WIRING			20620 -	20620 -	
45. LIGHTING FIXTURES			6180 -	6180 -	
46. ELEVATORS, ESCALATORS, DUMB WAITERS			-	-	
47. AUTOMATIC SPRINKLER SYSTEM					
48. MAIL CHUTE					
49					
50					
51					
52					
53					
54.	-	-	-	-	
55. TOTALS	111952 -	99768 -	245569	46 4689 -	
56.	TOTAL COST			46 4689 -	
57.	PROFIT			4644 -	
58.	SURETY BOND			5200 -	
59.	AMOUNT OF BID			51 5658 -	

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Summary of Estimate or "Cap" Sheet for Summarizing the Complete Estimate on One Sheet.

These items should be estimated for a year and then reduced to a certain percentage of the total annual business, as follows:

Principals' Salaries*	$.....	$24,000
Rent	.....	3,600
Fees paid to Consultants*	.....	400
Duplication	.....	50
Postage	.....	50
Travel & Entertainment*	.....	500
Automobile Expense*	.....	500
Utilities	.....	250
Offices Supplies	.....	250
Telephone & Telegraph*	.....	500
Employees' Salaries*	.....	25,000
Taxes & Social Security	.....	1,200
Dues	.....	250
Books & Periodicals	.....	150
Contributions	.....	150
Insurance*	.....	2,500
Depreciation	.....	250
Amortization	.....	
Hospitalization	.....	
Advertising	.....	250
Miscellaneous	.....	150
	$.....	$60,000

The above list is much larger than smaller contractors will have and considerably less than that carried by larger contractors but it will serve as an example of the items that should be included as overhead or general expense.

For example, suppose you have an overhead expense of $60,000 per year, and do an annual business approximating $1,000,000. On this basis your overhead or general expense would average 6 per cent of the total annual business.

With some concerns the overhead may run 6 per cent and with others 10 to 15 per cent of the total annual business but every contractor can approximate his overhead based on his average yearly business. Even an approximate is far better than not making any attempt in this direction.

Many smaller contractors do not maintain an office and probably attend to the greater part of their office duties them-

*Indirect expenses only, that is, those not reimbursed by fees from individual jobs.

selves, so only such items of expense as they actually incur should be included.

Should a Contractor's Overhead Expense Be Added to His Estimate?

Proposals for jobs taken on a time and material basis and provisions for extra work on jobs taken on a stipulated sum basis may require the contractor to state the percentage to be added for overhead, plus that for profit. In a recent job bid from five medium sized contractors in Chicago, these varied as follows: 8+4, 8+7, two at 10+5 and one at 10+10, so while overhead percentages varied only from 8 to 10%, the profit varied from 4 to 10%.

Whether these same percentages were used in figuring the base bid is, of course, each contractor's secret. But certainly, some addition to cover office overhead should be made unless the organization is so successful that the year's overhead has already been absorbed by other jobs; or that the work is of such nature that it is primarily subcontracted and office expenses are minor.

All manufacturers, jobbers and retailers add their overhead expense to the cost of their products when computing the selling price and there is no reason why contractors should not do the same—always keeping their eye on the competition.

Office Furniture and Equipment

All expenditures for office furniture, typewriters, calculating machines, filing cabinets, etc., should be kept as a separate account and a certain percentage of this amount charged off each year as depreciation. The depreciation, however, should be charged as a part of the overhead expense of conducting the business, as the cash value of the equipment decreases each year.

Construction Plant and Equipment

Construction plant and equipment costs are not directly chargeable to overhead, as they retain a cash value, but certain uniform percentages should be charged each year as depreciation.

The Internal Revenue Department publishes fixed schedules of allowed depreciation. However, certain tools and equipment may be necessary to undertake one particular job. These are direct job costs, not overhead, although if the equipment is retained after the job is completed, it would be depreciated for its remaining useful life.

Some contractors set up a "rental" cost for equipment owned by the firm but chargeable to individual jobs. Today the trend is to rent tools and equipment from outside firms specializing in

this which simplifies bookkeeping—all costs are directly charged to the job and no depreciation need be carried—and frees the contractor's capital for more lucrative investment. A discussion of plant and equipment is included as part of the next chapter.

INSURANCE

Insurance costs directly chargeable to office overhead would include fire and theft for office property, liability for office premises, workman's compensation for office employees, and automobile insurance for trucks and cars owned by the firm.

As liability insurance is a must in today's construction, this is also often included as an office overhead, a necessary cost of doing business. However, if the policy has rather low limits, the contractor will find that most specifications will require that he take out additional coverage, and this would be a job rather than overhead expense.

Surety bonds, performance bonds, property insurance for work under construction and workman's compensation, for on-job employees can be charged directly to the job costs and are discussed in the next chapter. The cost of bid bonds for work awarded to another contractor would obviously have to be absorbed by office overhead.

WHAT PERCENTAGE SHOULD THE CONTRACTOR ADD FOR PROFIT?

The amount of profit to be added to the estimated cost of the work is a question which a contractor must answer individually for each bid. There is no set amount that can be added. It all depends on local conditions, competition, and how badly the job is wanted.

On small jobs, alterations, remodeling and similar work, a contractor is justified in adding 20 to 25 per cent to the actual cost for profit, but whether he is able to obtain this amount each contractor must decide for himself.

On new work, where it is possible to estimate the cost with a fair degree of accuracy, a contractor is entitled to 10 per cent on the actual cost of the work (job overhead included in the actual cost of the job) but when submitting competitive figures it is safe to say there are many jobs let on a 5 per cent instead of a 10 per cent basis. A contractor is entitled to 10 per cent profit but getting it is another matter.

WHAT ABOUT CONTINGENCIES?

Another item that has caused considerable discussion is,

should a contractor add a certain percentage to his estimate to take care of contingencies? Yes and No.

Yes—because it is not necessary to be quite so careful in the preparation of the estimate and if any items have been overlooked, there is a fund to take care of omissions. But a contractor who is not careful in the preparation of his estimates never knows how much should be added to provide for forgotten items or contingencies.

No—because if you add a percentage for contingencies, it is quite possible that one or more of your competitors has not, and another job is lost.

The only safe way is to be as careful as possible in listing all items from the plans and specifications. Include them all and it will not be necessary to add for contingencies. This includes everything to be furnished and all labor costs including job overhead expense, and a percentage for profit.

An item often overlooked but which can become a major expense is the finishing up of a job and making corrections after the job is completed.

Often, there is confusion on the job at the end and it is difficult to say who chipped the paint, scratched the door, broke the window, stole the light bulb, broke the door handle, backed into the fencing, etc., as most of the trades are on the job doing touch-up work, the owner is moving in, his decorator is hanging drapes and his children running wild through the corridors. But the general contractor gets the complaint first and, in the interest of having a satisfied client, will probably assume the responsibility for correcting this.

In a warehouse, such problems may be minimal; in a fine residence, you might be called back daily for weeks.

ESTIMATE CHECK LIST

The following list includes nearly every item encountered in the construction of present day buildings.

It is intended as a reminder for the estimator, in order that the estimate may be compared with this list to see that all items have been included.

Please bear in mind that not all of the items on the following pages will be found in every building because the list is intended to cover every type of structure from the smallest residence to the largest skyscraper, commercial or industrial plant.

Compare it with your estimate before submitting your bid as it may be the means of including some items that would otherwise be omitted from your estimate.

This may require a few minutes extra time but always remember it is much better to be safe than sorry.

Forgetting has cost many a contractor his profit.

General Conditions.—Building Permit, Street Permit, Superintendent, Civil Engineer, Timekeeper, Material Clerk, Foremen, Watchmen, Waterboys, Temporary Office, Sheds, Tool Houses, Ladders, Stairways, Temporary Toilet, Temporary Heat, Temporary Water, Temporary Light and Power, Temporary Enclosures, Barricades, Partitions or Screens, Removing and Replacing Water Hydrants, Telephone and Telegraph Poles and Wires, Sewers and Drains, Protecting Adjoining Property and Buildings, Protecting New Work During Construction, Repairing New Work Damaged During Construction, Cutting and Patching for Other Trades, Removing Rubbish, Cleaning Floors and Windows, Surety Bond, Street Obstruction Bond, Workmen's Compensation or Employers Liability Insurance, Public Liability Insurance, Owners Contingent or Contractual Insurance. Contractors Contingent Insurance, Fire and/or Tornado Insurance, Contractors Equipment Floater Insurance, Old Age Pension and Unemployment Compensation Taxes, Sales Taxes, Surveys, Photographs, Telephone and Telegraph, Stationery and Job Office Supplies, Traveling Expenses, Contributions to Union Welfare and/or Pension Fund.

Plant and Equipment.—Power Shovels, Concrete Mixers, Pumpcrete, Hoisting Engines, Pumps, Air Compressors, Gasoline Engines, Saw Rigs, Chain and Power Saws, Derricks, Concrete and Material Hoisting Towers, Lifting Cranes, Gasoline and Oil, Concrete Buckets and Hoppers, Concrete Vibrators, Motor Trucks, Conveying Equipment, Excavating and Grading Machinery, Wheelbarrows, Wood and Metal Scaffolding, Concrete Buggies, Power Buggies, Salamanders, Mortar Mixers, Water Hose, Buckets, Picks, Shovels, Sledges, Temporary Electric Service, Miscellaneous Small Tools, etc.

Clearing Site and Wrecking Old Buildings.—Removing Old Trees and Stumps, Clearing Underbrush, Wrecking Old Buildings, Foundations, and Retaining Walls. Removing Old Materials from Premises, etc. Shoring and Underpinning Old Buildings.

Street and Underground Work.—Laying Out Work, Sewer Mains and Service Sewers, Water Mains and Service Pipes, Gas Mains and Service Pipes, Catch Basins, Man Holes, Conduit for Electric Wiring, Excavating and Grading Streets, Curb, Street Pavement, Sidewalks, Street Lights, Grading and Seeding Lawns and Parkways, Trees and Shrubbery, Electric Service, Telephone Service, etc.

Excavating and Back-Filling.—Basement, Sub-basement, Piers, Footings, Pits and Trench Excavation, Back-Filling, Grading and Filling, Shoring and Blasting, Loading and Trucking.

Caissons.—Excavating, Hoisting and Removing Excavated Earth, Wood Lagging, Metal Rings, Concrete, Reinforcing Steel, etc.

Wood, Concrete or Steel Piling.—Wood, Steel, Composite or Concrete Piles, Wood or Steel Sheet Piling, Special Foundations, Shoring and Underpinning.

Foundations and Retaining Walls.—Wood or Metal Forms, Reinforcing Steel, Concrete for Foundations, Footings, Piers, Retaining Walls, Machinery Foundations, etc. Foundations and Retaining Walls of Rubble Stone, Cut Stone, Sewer, Common or Paving Brick, Cement Blocks, Vitrified Tile, etc.

Water and Dampproofing.—Integral, or Membrane Waterproofing, Waterproof Paints or Plaster Coats for Basement or Foundation Walls, Boiler Rooms, Sump Pits, etc. Waterproof Paints or Compounds for Interior or Exterior Brick, Tile or Concrete Masonry Walls, Back-painting Stone or Marble, Waterproofing Cement or Concrete Floors. Concrete Hardener and Dustproofing Compounds.

Cement Finish Floors, Walks and Pavements.—Sidewalks, Basement Floors, Concrete Areaways, Porch Floors, Concrete Steps, Concrete Driveways, Concrete Floor Fill between Wood Sleepers or Screeds, Concrete Floor Fill under Tile, Marble, Terrazzo or Composition Floors, Cinder or Slag Concrete Fill, Vermiculite, Pumice or other lightweight Concrete or Fill, Roof Saddles, Cement Finish Floors and Base, Nailing Concrete, Composition Floors and Base.

Brick Masonry.—Face or Press Brickwork, Enamel or Glazed Brickwork, Paving Brick, Fire Brick, Common Brick, Hollow Brick, Sewer Brick, Bricking-in Boilers, Catch Basins, Manholes, Brick Stacks, Wall Coping, Flue Lining, Brick Mantels, Fire-brick Lining, Hearths and Back-hearths, Glass Blocks, Cleaning and Pointing Brickwork, Drain Tile, Scaffolding, Mortar, Mortar Color, Wall Ties.

Concrete Masonry.—Concrete Blocks for Foundation and Basement Walls, Interior and Exterior Walls and Partitions, Trucking, Scaffolding, Mortar, Labor Handling and Setting Blocks.

Cut Stone and Exterior Marble.—Cost of Stone at Quarry or Mills, Freight, Trucking, Cutting, Carving, Lewising, Metal Anchors, Scaffolding, Labor Handling and Setting Stone, Mortar, Back-painting or Back-plastering Stone, Cleaning and Pointing, Derricks, Hoisting Engines, etc.

Granite.—Cost of Granite at Quarry or Mills, Freight, Trucking, Cutting, Carving, Lewising, Metal Anchors, Scaffolding, Labor Handling and Setting, Mortar, Back-painting or Back-plastering, Cleaning and Pointing, Derricks, Hoisting Engines, etc.

Terra Cotta.—Cost of Terra Cotta at Factory, Freight, Trucking, Metal Anchors, Filling with Concrete, Scaffolding, Labor Handling and Setting, Mortar, Cleaning and Pointing.

Reinforced Concrete.—Wood or Metal Forms for Reinforced Concrete Floors, Beams, Girders, Columns, etc. Wood Forms for Reinforced Concrete Stairs, Platforms and Landings. Reinforcing Steel, Freight, Trucking, Cutting and Bending, Handling, Hoisting, Placing and Tying in place. Clay Floor Tile, Metal Tile or "Pans," Concrete Soffitile. Labor Handling, Hoisting and Placing Floor Tile or Soffitile. Cement, Sand, Gravel, Slag, Cinders or Crushed Stone. Unloading and Handling Materials. Mixing, Hoisting and Placing Concrete, Heating Materials in Freezing Weather, Anti-Freeze Compound, Frost Protection, Tarpaulins, Salamanders, Fuel, Straw, etc., for placing and protecting concrete during freezing weather. Removing Forms and Cleaning Lumber. Precast Concrete Joists, Flexicore and Precast Floor Slabs, Precast and Poured Gypsum Roof Decks.

Architectural Concrete.—Wood or Metal Forms, Plywood, Concrete Form Presdwood, Wood or Plaster Waste Molds, Rustication Strips, Fluting or Other Ornamentation, Bolts, Wall Ties, Form Oil or Lacquer, Scaffolding, Labor Building, Erecting and Removing Forms. Reinforcing Steel, Labor Handling, Placing and Tying. Cement, Sand, Gravel or Stone for Concrete. Labor Mixing and Placing Concrete. Labor Patching Bolt Holes and Grouting Concrete Wall Surfaces.

Clay and Gypsum Hollow Tile.—Tile Floor Arches, Column, Beam and Girder Covering. Tile Partitions and Wall Furring. Gypsum or Plaster Block Partitions and Wall Furring. Structural Tile for Bearing Walls, Tile for Backing up Brickwork. Tile Floor Fill and Furring, Book Tile, Structural Roof Tile, Structural Glazed Tile, Salt Glazed Tile, Clear Glazed Tile, Ceramic Glazed Tile. Tile for Foundations and Basement Walls, Freight, Trucking, Scaffolding, Mortar, Labor Handling and Placing.

Rough Carpentry. -Wood Roof Trusses, Framing Timbers for Columns, Beams, Girders and Heavy Joists, Floor and Ceiling Joists, Roof Framing, Laminated Floors, Heavy Factory Floors, Subflooring and Roof Sheathing, Roof Saddles, Porch Framing, Columns, Balusters and Balustrade, Porch Ceiling, Exterior Wood Steps, Wood Furring Strips for Walls and Floors, Wood Porch Floors, Plywood Wall and Roof Sheathing, Subflooring,

etc. Stud Walls and Interior Partitions, Bridging and Trussing, Wood Sidewall Sheathing, Drop Siding, Novelty Siding, Clapboarding, Wood Shingle Siding, Asphalt and Asbestos Shingle Siding, Exterior Woodwork, such as Watertable, Corner Boards, Cornice Work, M. & B. Soffits, Quarter Round, Cove, Facia Boards, Panel Strips, Pergola Rafters, Ornamental Roof Rafters, Rough Stairs, Wood Grounds and Window Blocking, Rough Wood Bucks for Doors and Borrowed Lights, Sliding Door Pockets, Wood Centers for Doors and Windows. Wood Lintels, Deadening Felts, Building Paper, Floor and Wall Insulation and Deadening, Coal Bins, Fruit Rooms, Caulking Exterior Door and Window Frames, Weather Strips, Hook Strips, Wood Shelves, Clothes Posts, Wood Fences and Gates, Finish Floors, etc.

Hardwood and Parquetry Floors.—Hardwood or Parquetry Flooring, Wood Block Flooring, Plank Flooring, Labor Handling, Laying, Scraping, Planing, Sanding, etc.

Mill Work and Interior Finish.—Door and Window Frames, Sash, Exterior and Interior Doors, Kitchen Cases and Cabinets, China Cases, Pantry Cases, Bookcases, Breakfast Room Tables and Benches, Mantel Shelves, Wardrobes, Linen Cases, Wood Mantel Fronts, Door Jambs, Door and Window Trim and Casings, Stops, Picture Mould, Chair and Wainscot rail, Wood Wainscoting, Wood Base, Panel Strips, Plywood Walls, Wood Cornice, Shelf Cleats, Garage, Barn and Factory Frames and Doors, Casement Doors and Windows, Sliding Doors, Wood and Glass Partitions, Outside Shutters or Blinds, Exterior Porch Materials, Columns, Bases, Caps, Newels, Balustrade, Balusters, Crown Mouldings, Bed Mouldings, Quarter Round, Cove Mould, Lattice Strips, Window and Door Screens, Storm Doors and Sash, etc. Labor Handling and Erecting all Classes of Mill Work and Interior Finish.

Wood Stairs.—Well Hole Facing, Stringers, Treads, Risers, Half-Circle Treads and Risers, Newels, Landing Newels, Balustrade, Balusters, Cove Mould, Paneled Facia Stringers, Housing Stringers, Labor Making and Erecting Stairs.

Wall and Insulating Board.—Wood Furring or Nailing Strips between Wood Studs or Ceiling Joists, Vapor-Seal Sheathing, Insulating Sheathing, Plywood or Insulating Wallboard, Insulating Plank, Insulating Tile, Gypsum Wallboard, Hardboard, Metal, Wood or Fiber Mouldings, etc. Labor Handling and Placing.

Wall and Ceiling Insulation.—Rock, Glass, or Mineral Wool Insulation, Batts or Loose. Cotton Insulation; Wood Fiber or Other Strip or Quilt Insulation for use between Floor and Ceil-

ing Joists, Studs, etc. Fiberglas, Foamglas or Other Board Form Insulating Materials. Aluminum Foil or Sheet Steel Insulation. Sprayed on Insulation, Acoustical Tile, Attached or Suspended.

Wood and Metal Lathing and Furring.—Wood Lath, Nails, Labor, Metal Studding, Channel Iron, Round Rods, Metal Lath, Tie Wire. Wall and Ceiling Furring, Suspended Ceilings, Solid Metal Partitions, Metal Furring for Ornamental Plaster Cornices, Beams, Columns, etc. Gypsum or Rocklath, Nails, Labor Handling and Placing. Insulating Lath. Metal Door and Window Trim. Corner Beads, Base Beads, etc.

Plastering, Plain and Ornamental.—Plain Interior Plastering, Perlite or Vermiculite Plaster, Keene's Cement Base and Wainscoting, Portland Cement Base and Wainscoting, Ceiling and Wall Coves, Exterior Plaster or Stucco, Imitation Caen Stone Plaster, Acoustical Plaster, Ornamental Plaster Cornices, Beams, Columns, Bases, Caps, Wall and Ceiling Panels.

Hollow Metal Doors and Windows.—Hollow Metal Window Frames and Sash, Door Frames and Jambs, Casings, Doors, Entrance Features, Hardware, Glass, Freight, Trucking, Labor Erecting.

Kalameined Iron Work.—Door and Window Frames, Doors, Windows, Tin Clad Doors, Shutters, Trap Doors, Track and Hardware, Fusible Links, Freight, Trucking, Labor Erecting.

Steel and Aluminum Sash, Windows and Casements, Partitions and Doors.—Steel or Aluminum Sash, Ventilating Units, Mullion Bars, Segment Heads, Saw Tooth and Monitor Sash, Double Hung and Casement Windows, Screens, Storm Windows, Solid Steel Partitions, Doors, Rolling Steel Shutters, Steel Doors, Hollow Metal Partitions, Glass, Glazing Compound, Hardware, Freight, Trucking, Labor Erecting. Caulking and Pointing.

Art Metal Doors, Trim and Furniture.—Art Metal Door and Window Frames, Doors, Sash, Door Jambs, Elevator Doors, Hangers, Track and Hardware, Door and Window Trim and Casings, Borrowed Lights, Transoms, Metal Base, Picture Mould, Chair Rail, Cornices, Wainscoting, Desks, Lockers, Filing Cabinets, Chairs, Mouldings, Hardware, Freight, Trucking, Labor Erecting.

Metal Joists—Pressed Steel "I" Beams or Joists, Trussed Joists, Channels, Partition Studs, Stran-Steel Joists and Studs, Bridging, Beam Clips, Furring Clips, Connection Angles, Bearing Plates, Joist Hangers, Metal Lath and Channel Iron for Suspended Metal Ceilings, Metal Lath Floor Covering, Nails,

Connection Bolts, Rivets, Etc. Freight, Trucking, Labor Handling and Erecting.

Sheet Metal Work.—Metal Gutters, Braces, Eaves Trough, Conductor Pipe, Elbows, Shoes, Strainers, Cut-Offs, Conductor Hooks, Eaves Trough Hangers, Tin, Galvanized, Aluminum and Copper Flashings and Counter Flashings, Hips, Valleys, Chimney Flashing, Hip and Ridge Roll, Metal Cornices, Mouldings, Skylights, Ventilators, Metal Ceilings, Steel Siding, Tin, Aluminum, Steel, Lead and Copper Roofing. Glass, Glazing Compound, Painting, Freight, Trucking, Labor Handling and Erecting.

Roofing.—Wood Shingles, Prepared Roll Roofing, Composition Roofing, Asphalt Shingles, Asbestos Shingles, Metal Shingles, Imitation Tile Roofing, Tile Roofing, Slate Roofing, Concrete Tile Roofing, Hips, Valleys and Flashing, Freight Trucking, Labor, Corrugated Metal or Asbestos Roofing and Siding, Nails, Clips, Labor, etc.

Tile and Mosaic.—Ceramic, Plastic, Aluminum or Steel Wall Tile. Mosaic, Quarry Tile, Asphalt, Linoleum, Plastic or Composition Floor Tile, Rubber Tile, Cork Tile, Terrazzo Floors and Base, Tile Base, Wainscoting and Cap, Tile Built-in Fixtures, Tile Mantels, Hearths and Back Hearths, Cement Fill under Floors. Adhesives, Freight, Trucking, Labor. Linoleum Floors.

Interior Marble and Slate.—Marble Floor Tile, Base Wainscoting, Cap, Partitions, Treads and Risers, Stringers, Fascia, Handrail, Balustrade, Balusters, Bases, Caps, Mouldings, Statuary, Shower Floor Slabs, Backs and Partitions, Door and Window Casings, Hardware, Freight, Trucking, Labor Handling and Erecting. Slate Blackboards, Partitions, Base, Floor Slabs, Floor Tile, Bath Partitions, Treads and Risers, Laundry Tubs, Hardware, Freight, Trucking, Labor Handling and Erecting.

Art Marble and Scagliola.—Art Marble Floor Tile, Door and Window Trim and Casings, Wainscoting, Base, Cap, Column and Pilaster Bases and Caps, Columns, Pilasters, Wainscoting, Stair Treads and Risers, Fascia, Freight, Trucking, Labor Erecting.

Glass and Glazing.—Window Glass, Plate Glass, Thermopane or Twindow, Mirrors, Leaded or Other Art Glass, Structural Glass, Plain or Ribbed Wire Glass, Obscure Glass, Prism Glass, Miscellaneous Glass, Putty, Freight, Trucking, Labor Glazing.

Painting, Varnishing and Decorating.—Painting Exterior Door and Window Frames, Doors, Windows, Siding, Porch

Floors and Ceilings, Cornices, Porches and Steps, Exterior Iron and Sheet Metal Work. Interior Finishing, Floors, Doors, Windows, Casings, Base, Picture Mould, Chair Rails, Wood Cornices, Bookcases, Mantels and Shelves, Kitchen and Pantry Cases, Wardrobes, Medicine Cases. Painting Walls and Ceilings. Tinting Walls and Ceilings, Enamel Work, Cold Water Paint, White Washing, Wall Paper, Sanitas Wall Covering, Linawall, Canvas Walls and Ceilings, Paper Hanging.

Structural Iron and Steel.—Iron Castings, Grillage, Structural Columns, Girders, Beams, Roof Trusses, Crane Tracks, Bolts, Riveting or Welding, Rivets, Freight, Trucking, Unloading, Handling and Erecting, Painting. Cast Iron Columns, Bases and Caps, Steel Stacks, Junior I Beams, Freight, Trucking, Erection, Painting.

Miscellaneous Iron and Steel.—Area Gratings, Manhole Covers, Coal Chutes, Fireplace Dampers, Ash Traps, Cleanout Doors, Cast Iron Bumpers, Iron or Steel Bases and Caps for Wood Columns, Joist Hangers, Wall Anchors, Pin Anchors, Wall Plates, Straps, Garbage Receiver, Package Receivers, Window Guards, Pipe Railing and Fittings, Fireplace Frames, Wire Spark Guards, Prismatic Sidewalk Lights, Sidewalk Doors, Metal Lockers, Medicine Cases, Steel Stair Nosings, Vault Doors, Concrete Inserts, Wall Safes, Fire Extinguishers.

Cold Storage Insulation.—Cork, Fiberglas, Foamglas or Other Insulation for Refrigerators, Cold Storage Warehouses, Partitions, Walls, Floors, Ceilings, Mortar, Asphalt, Steel "T" or Angle Partition Supports, Freight, Trucking, Labor. Wall, Ceiling, and Roof Insulation against Heat and Cold. Cost of Insulation, Freight, Trucking, Labor.

Ornamental Iron, Aluminum, Stainless Steel, Brass and Bronze.—Iron Stairs, Fire Escapes, Entrance Doors, Elevator Doors and Enclosures, Window Guards, Prismatic Lights, Treads and Risers, Newels, Balusters and Balustrade, Ornamental Posts, Lamps and Lanterns, Doors and Frames, Standards, Tablets, Partitions, Railings, Grilles, Thresholds, Push Plates, Railings and Gates, Ornamental Store Fronts, Gates, Signs, Freight, Trucking, Labor Handling and Erecting.

Rough and Miscellaneous Hardware.—Nails, Screws, Bolts, Anchors, Pin and Strap Anchors, Sash Cord or Chain, Sash Weights, Sash Pulleys, Sash Balances, Window Fixtures, Expansion Bolts, etc. Sliding Door Pockets, Tracks and Hangers. Garage Door Hardware. Window Cleaning Bolts.

Finish Hardware. Butts, Door Locks, Escutcheon Plates, Push Plates, Door Holders, Door Checks, Window Lifts, Locks,

Burglar Locks, Cremone Bolts, Casement Window Adjusters and Fasteners, French Door Hardware, Floor Checks, Panic Bolts, Kick Plates, Bookcase Hardware, Cupboard Hardware, etc.

Plumbing, Gas Fitting and Sewerage.—Excavating and Backfilling for Sewers, Cast Iron or Tile Sewer Pipe, Labor Placing. Soil Pipe, Pipe and Fittings, Hot and Cold Water Supply, Fixtures, such as Bathtubs, Sinks, Showers, Water Closets, Lavatory, Drinking Fountains, Laundry Tubs, Pipe Covering, Freight, Trucking, Labor. Gas Pipe, Fittings, Automatic Water Heaters, Connecting Gas Stoves, Gas Logs, Heaters, etc.

Heating.—Steam or Hot Water Boilers, Smoke Pipe, Pipe and Fittings, Convectors, Baseboard or Upright Radiators. Radiant Panel Heating in Floors, Walls or Ceilings. Valves, Air Vents and Valves, Painting, Freight, Trucking, Labor, Thermostat, Pipe Covering. Warm Air Furnaces, Blowers, Humidifiers, Precipitron, Pipe and Fittings, Ducts, Registers, Thermostat, Smoke Pipe, Freight, Trucking, Labor Installing. Warm air Radiant Heating. Oil Burners, Stokers.

Ventilating and Air Conditioning.—Air Washers, Humidifiers, Ventilators, Fans, Metal Ducts, Refrigerating Equipment, Motors, Controls, Freight, Trucking, Labor Installing.

Power Plant Equipment.—Boilers, Engines, Dynamos, Transformers, Pumps, Switch Boards, Cranes, and Conveying Machinery, Refrigerating Machinery, Stokers, Machine Foundations, Pipe Covering, Freight, Trucking, Labor Installing.

Electric Wiring.—Conduit, Outlet Boxes, Floor Boxes, Wire, Switches, Speaking Tubes, Mail Boxes, Bells, Telephones, Watchmen's Clocks, Base Plugs, Bracket Outlets, Radio and Television Outlets, Service Boxes, Transformers, Freight, Trucking, Labor. Power Wiring for Electric Cooking Ranges, Ventilating Fans, Garbage Disposals, Electric Dishwashers, Freezers, Washing Machines, Dryers, Mangles, Water Heaters, Garage Door Operators, etc.

Lighting Fixtures.—Electric Ceiling Lights, Bracket Fixtures, Lamps, Freight, Trucking, Labor Installing. Gas Ceiling Fixtures, Bracket Fixtures, Labor Installing. Combination Gas and Electric Fixtures.

Elevators and Dumbwaiters.—Sidewalk Lifts, Dumbwaiters, Freight or Passenger Elevators, Tracks, Doors, Hangers, Enclosures, Hardware, Signal Devices, Ash Hoists, Freight, Trucking, Labor Installing. Escalators.

Vacuum Cleaning System.—Pipe and Fittings, Vacuum Cleaner, Motors, Hose and Appliances, Electrical Outlets and Connections, Freight, Trucking, Labor Installing.

Automatic Sprinkler System.—Pipe and Fittings, Tanks,

Pumps, Motors, Engines, City Main Connections, Sprinkler Heads, Valves, Freight, Trucking, Labor Installing.

Mail Chute.—Cost of Mail Chute Installed in the Building.

Laundry Equipment.—Laundry Tubs, Heaters, Washing Machines, Mangles, Dryers, Freight, Trucking, Labor Installing.

Kitchen Equipment.—Wood or Metal Kitchen Cases or Cabinets. Gas or Electric Ranges, Ice or Mechanical Refrigerators. Electric Dishwashers, Garbage Disposal Unit, Ventilating Fans, Combination Kitchenette Cabinets.

Miscellaneous Equipment.—Window Shades, Venetian Blinds, Curtain Rods and Brackets, Radiator Covers and Humidifiers, Hall and Stair Carpets, Window Screens, Storm Sash, Garbage Cans, Garbage Incinerators, Wall Beds, etc. Pneumatic Tubes and other Mechanical Devices. Wood and Metal Lockers, Metal Hospital Cases and Cabinets, X-Ray Equipment, Lead Lined Blocks.

CHAPTER IV

ESTIMATING JOB CONDITIONS

Each job will entail certain expenses that are chargeable to the job as a whole. These are set forth in the General Conditions, the 14 articles of the AIA usually made a part of the Contract, and the Supplementary Conditions and/or General Requirement Section of the Specifications. These will include such items as superintendent, temporary buildings, enclosures, barricades, offices, toilets, utilities, protection, clean-up, permits, surveys, photographs, tools and equipment, insurance and benefits, sales taxes, surety bonds, and warranties.

Sometimes, these are covered only in a general way and it is up to the contractor to visit the site to determine what is needed. Often the unions and local laws may be more demanding than the architect's specifications, and the contractor must know for what items he is liable.

As discussed in the preceding chapter, job overhead and office overhead are best kept separately, although occasionally employees' insurance, tools and equipment and other items may be divided between office expense and job expense.

Many contractors figure a certain percentage of the cost of the job to take care of all overhead expense and plant charges, but this is not the correct method to use and does not give the contractor or estimator a reliable basis for computing the cost of this work.

Each item entering into the cost of job overhead expense should be estimated the same as any other branch of work.

Superintendence.—This should include the salary and traveling expenses of the job superintendent, assistant superintendent, engineers, timekeepers, material clerks, watchmen, waterboys, labor foremen and all other foremen required to be carried on the general contractor's payroll.

The proper method of computing these costs is to estimate the salaries of the various men required at a certain price per week or per month for the entire estimated time they will be required on the job.

Temporary Buildings and Enclosures.—This should include temporary fences, bridges, or platforms, temporary sheds and storerooms, temporary enclosures over hoisting engines, concrete mixers, etc., temporary runways, ladders and stairs in the building before the permanent stairs are installed, temporary dustproof partitions to isolate work areas from building space still occupied, and temporary closures for doors and windows before the permanent doors and windows are in place. One-quarter inch plywood on 2 x 4s will run around 50¢ p.s.f.; 12 oz. tarpaulins will run 12¢ p.s.f.

Temporary Office.—This should include the temporary job office for use by the contractor and architect during construction, together with all necessary expense in maintaining same, such as telephone, heat, light, stationery, and other items of expense. These are usually trailers, which may be rented. An 8′ x 30′ trailer, furnished, will cost around $2800.00.

Barricades and Signal Lights.—This should cover the cost of building and maintaining barricades during construction, cost of maintaining signal lights, etc.

Temporary Toilet.—Practically every job must have some provision for sanitary facilities. On small jobs a pit dug into the ground with a rough shed erected over it will be sufficient. On large jobs, however, a more elaborate setup is usually specified requiring a complete water supply, drain, vent and fixture installation. This work is sometimes included in the plumbing specifications. Chemical toilets can be rented for about $40.00 per month.

In the case of a remodeling job where permission is granted to use the existing facilities, an item should be included in the estimate for periodic and final cleaning of the toilet room and its appurtenances.

Temporary Water.—On most jobs water for construction purposes must be provided by the general contractor for all trades. This item can become a high-cost operation especially in barren, undeveloped localities where either a well must be drilled or water must be hauled into the job. Where water mains are in existence, a plumber must be engaged to tap same, install water meter and run a water line to strategic locations on the job. This work is sometimes included in the plumbing specifications. Also included under this heading are the charges made by the local water department for the volume of water used. Often hydrants can be used at a set fee from the municipality.

Temporary Light and Power.—This item can vary from a small charge for tapping into existing adjacent power lines and run-

ning entrance cable into a meter setup from which extension cords may be run as desired to complex installations requiring long run pole lines, transformers, switch gear, etc., as in the case where electric mixers, hoists and other heavy duty electric power equipment is to be used. This work is sometimes included in the electrical specifications. Also included in this item are the power company charges for energy consumed and rental of transformers, etc.

Temporary Heat.—If a job is to run into or through a winter it is very likely that some temporary heat will be required to maintain proper working conditions for the continuance of the construction work. On small jobs a few salamanders may be enough to fulfill the requirements. Large jobs, however, usually require temporary hook-up of radiators to the new and as yet uncompleted heating system. When this occasion arises the boiler usually must be tended by steamfitters working 3 shifts and the labor cost is quite high. Also to be included in this item is the cost of all fuel consumed.

Repairing Streets and Pavements.—This item should cover the repair and replacement of all sidewalks and pavements damaged or destroyed during construction.

Damage to Adjoining Buildings.—There is always a chance of damage to adjacent structures, such as breaking windows, damaging foundations and walls improperly shored, damaging skylights, etc., and these items should be considered when preparing the estimate.

Protecting New Work from Damage During Construction.—During construction there are certain classes of work that must be protected from damage, such as cut stone, marble, terra cotta, granite, etc., also covering newly finished cement or wood floors to prevent damage pending the acceptance of the work by the owner.

Repairing New Work Damaged During Construction.—This item should cover patching of damaged plaster, replacing broken lights of glass, etc. Quite often architects specify the cost of such repair work to be prorated among the various contractors working on the job unless specific responsibility for the damages can be charged to an individual contractor.

Cutting and Patching for Other Trades.—Many specifications require the general or mason contractor to do all cutting and patching of walls and floors for the plumbing, heating and electrical contractors, where it is necessary for the mechanical trades

to place sleeves or pipes through the floors or walls after the permanent work is in place.

Removing and Replacing Public Utilities.—In the larger cities it may be necessary to remove or relocate water hydrants, poles and wires of telephone, telegraph, or electric light companies, sewers and drains, or other underground pipes pending the installation of certain portions of the new construction work and in such instances it will be necessary for the contractor to pay for any damage incurred.

Removing Rubbish, Cleaning Floors, Windows, Etc.—During the construction of every building there is always a certain amount of rubbish, such as old concrete, broken bricks, tile, etc., that must be removed at intervals. The most satisfactory method is to estimate so many loads of rubbish at a certain price per load.

If finish floors are to be swept or scrubbed before acceptance of the building by the owner, it is advisable to make a certain allowance to provide for this work. Ninety-five cents per 100 sq. ft. should cover this.

Some architects require the contractor to clean all windows before the building will be accepted. To arrive at this cost, count the windows and allow a certain price for cleaning each window, generally around 5¢ per sq. ft., 2 sides.

Building Permits.—The cost of building permits varies with the city in which the work is to be performed. Some cities base the cost of the permit on the total cost of the work, or the cubical content of the building, while others charge for water consumed, street frontage occupied, and the number of plumbing fixtures, for which an inspection charge is made.

As a general rule a building permit will cost from $\frac{1}{10}$ to $\frac{1}{4}$ of 1 per cent of the total cost of the building.

In Chicago permit fees are charged as follows:

(a) Single car garage, two car garage, and shelter sheds: For each 1,000 cubic feet or fractional part, $4.00; minimum charge, $10.00.

(b) New buildings or other structures, except those included in (a): For each 1,000 cubic feet of volume or fractional part, $1.25; minimum charge, $20.00. Volume computations under (a) and (b) shall include every part of the building from the basement to the highest point of the roof and include bay windows and other projections.

(c) Alterations and repairs to any structures: For the first

$1,000.00 of estimated cost, $7.75; for each additional $1,000.00 of estimated cost, $3.00; minimum charge, $20.00.

(d) Shoring, raising, underpinning or moving any building: For each 1,000 cubic feet of volume or fractional part, 40 cts.; minimum charge, $20.00.

(e) Wrecking any building or other structure more than one story in height: For each 25 lineal feet of frontage or fractional part, $13.00; minimum charge, $20.00.

(f) Fire Escape, erection or alteration: Four stories or less in height, $20.00; each story above four, $2.75.

(g) Canopy or marquee, erection or alteration, $20.00.

(h) Chimneys, isolated or over 50 feet above any roof, $20.00.

(i) Tanks, above roof or tower: 400 gallon capacity or less, $13.00; over 400 gallon capacity, $25.00; structural supports for tank over 400 gallon capacity, $25.00.

(j) Elevators and escalators—Power operated, five floors or less in height, installed or altered, $20.00; each additional floor above five, $4.00; hand operated, $13.50; levelators, $13.50; theater curtains, $50.00; stage or orchestra platforms, $20.00.

Dumbwaiters—Power operated, five floors or less in height, installed or altered, $20.00; each additional floor above five, $4.00. Hand operated, five floors or less in height, $13.00; each additional floor above five, $2.75. Temporary construction towers over 50 feet in height $20.00.

(k) Amusement Devices, mechanical riding, sliding, sailing or swinging: Portable—for each assembly or installation, $12.50. Permanent—installed or altered, $105.00. Temporary seating stands, $70.00.

(l) Ventilating Systems—mechanical supply or exhaust: Capacity, 3,000 cubic feet of air per minute, $10.50; for each additional 1,000 cubic feet per minute, $3.00; increase in capacity, each 1,000 cubic feet per minute, $3.00. Capacity shall be the sum of supply and exhaust. Warm air furnaces, $12.50 each.

(m) Fences over 5 feet high, 100 lineal feet, $10.00; each additional 100 lineal feet or part thereof, $3.00.

(n) Tanks for flammable liquids: Classes I and II: Capacity 121 to 500 gallons, $21.00; each additional 1,000 gallons or fraction thereof, 65 cts.; Classes III and IV: Capacity 551 to 1,000 gallons, $21.00; each additional 1,000 gallons or fraction thereof, 40 cts.

(o) Temporary Platforms for Public Assembly Units, $21.00.

(p) Roof of any building, recoating or recovering, $6.50.

(q) Billboards and signboards—erection, construction or alteration: up to 150 sq. ft. $5.00; 151 to 225 sq. ft. $7.75; 226 to 375 sq. ft. $13.00; for each additional 375 sq. ft. or part thereof $13.00.

A fee of $20.00 shall be paid to the city collector for the approval of plans, and inspection, and test, of any plumbing within any building containing not more than five plumbing fixtures. An additional fee of $3.00 shall be paid for every plumbing fixture in excess of five within such building.

Surveys.—Where the contractor must furnish a survey of the property on which the building is to be erected, a charge of $125 to $250 is usually made for a lot up to 100′ x 100′. In the downtown sections of large cities this charge will be substantially more.

Photographs.—Where it is necessary to have photographs taken at intervals to show the progress of the work, the cost will vary with the number of views made at one time. In the larger cities it will cost $5.00 to $7.00 for the first photograph and $3.00 to $4.00 for each additional negative. Additional 8″ x 10″ prints mounted on muslin about $1.00 each. A minimum charge of $50 to $75 per visit is usual.

In the smaller towns and cities this cost may be reduced one-third.

CONTRACTOR'S TOOLS AND EQUIPMENT

When preparing an estimate on any job, the item of tools and equipment should be figured as carefully as any branch of work in the structure.

First, make a study of just what equipment will be required to execute the work economically, such as the number and size of concrete mixers, hoisting engines, hoisting towers, derricks, compressors, vibrators, etc. Also the number of wheelbarrows, concrete barrows or buggies, quantity of scaffolding, outriggers, lookouts, cables, picks, shovels, etc. Also gas, oil, etc., to run power equipment.

If the job is out of town it will be necessary to add freight and trucking to the job and for its return upon completion.

On some jobs it may be advantageous to rent or lease certain equipment, such as concrete mixers, hoisting engines, compressors, etc., and in such instances the rental should be based on the length of time required by each piece of equipment.

The following information on contractor's plant and equipment will assist the estimator in determining the most economical methods to use when figuring various size jobs.

Portable Belt Conveyors.—Some applications in the construction field require the use of portable belt conveyors of various sizes and capacities. Their flexibility does not limit the user to a fixed receiving or discharging point, and when used in series, this flexibility is still further increased to carrying of materials over long horizontal distances, over obstructions, around corners, etc.

Portable conveyors are available in boom lengths to 120 ft. and belt widths of 18", 24", 30" and 36". Swivel wheels permit building

Portable Conveyor With Vibrating Screen at Head End

of high capacity radial stock piles or discharge into any one of several bins or hoppers. Both single and multi-deck vibrating screens may be used at the discharge end to separate the material into two or three sizes. Feeder-trap and feeder-hopper units mounted at the tail end, permit charging by front end loaders, dozers, cranes, draglines, shovels or other conveyors.

Portable conveyors are used for conveying earth, clay, sand, gravel, stone, bulk cement, concrete, etc., from stock piles or to convey and elevate materials to trucks, etc. They are often used for conveying wet concrete from mixer to elevated structures where the incline is not too steep.

Conveyors are furnished with either plain or cleated belts

but the cleated belts should not be used with wet materials, such as wet concrete, wet clay, etc.

The illustrations show just how belt conveyors may be used for conveying wet concrete from one place to another.

Capacities of Standard Conveyors in Tons Per Hour (Based on the Assumption of Uniform and Continuous Loading)

Belt Width	Belt Speed Ft. per Min.	Earth Dry	Clay Dry	Sand	Stone Gravel	Bulk Cement
18″	300	112	92	150	160	150
24″	300	215	185	290	315	290
30″	300	350	300	470	510	470
36″	300	520	450	690	750	690

Sizes, Weights and Capacities of Contractor's Wheelbarrows

Struck Capacity Cu. Ft.	Heaped Capacity Cu. Ft.	Approx. Weight Pounds	Type of Materials Used for
2½	3½	74	Dry Materials
3	4	78	Dry Materials
3½	4½	75	Concrete-Mortar
4	5	79	Concrete-Mortar
4½	6	83	Concrete-Mortar

It requires about 150 shovels (No. 2 shovel) for one cu. yd.

Capacities of Concrete Mixers Based on A. G. C. Standards

(in Sacks of Cement per Batch)

Size of mixer denotes number of cubic feet of mixed concrete, plus 10 percent excess, when mixer is level.

Concrete Proportions	Sizes of Standard Mixers 3½-S	6-S	11-S	16-S	28-S
1 :1½ :3	½	1	3	4	8
1 :1½ :3½	½	1	2	3	7
1 :2 :3	½	1	2	3	7
1 :2 :3½	½	1	2	3	7
1 :2 :4	½	1	2	3	6
1 :2½ :4	½	1	2	3	6
1 :3 :5	½	1	1	2	5
1 :3 :6	½	1	1	2	4

Sizes, Weights and Capacities of Concrete Carts or Buggies

Capacity Cu. ft.	Turning Radius	Width Overall	Length Overall	Maximum Height	Approx. Weight
12	72″	34″	87 ″	54″	950
15	82″	41″	94½″	54″	1020
21	91″	54″	106½″	56″	1400

Cutting Masonry Products With Portable Masonry Saw*

On practically every construction job there is a large amount of cutting necessary on masonry materials and with the high cost of labor this becomes an expensive item especially when the cutting is done by hammer and chisel.

This applies particularly to the cross and diamond bonds in brick masonry, arch brick, radial brick, glazed tile, rotary kiln blocks, concrete blocks, natural stone, roofing tile, conduits, etc.

Compact Masonry Saw

By using a masonry saw, this work can be done at a fraction of the cost of hand cutting plus the saving of materials.

Masonry saws are obtainable with 12", 14", 18" and 20" blade capacities; prices range from $395.00 up. Saws are designed for both wet (dustless) and dry cutting. The advantage of wet cutting is in confined areas where dust would be a problem. An exhaust

*Norton Construction Products Division, Kansas City, Mo.

assembly is available for use with dry cutting masonry saws—this assembly consists of a high velocity fan that draws the dust away from the machine and disposes of it through the nearest opening. The price of the clipper exhaust assembly is $135.00.

A smaller compact model masonry saw has recently been developed. This model is light enough for a man to carry and may be set up on the scaffolding or operated from a pickup truck or the back of a station wagon.

Recently developed also is a small, highly portable concrete saw which can do the work of many of the heavier models.

There are four types of blades that can be used on masonry saws: (1) wet-dry abrasive blades; (2) dry "break-resistant" abrasive blades; (3) wet "break-resistant" abrasive blades; (4) diamond blades. The wet abrasive and Diamond blades should be used only with a masonry saw equipped for wet cutting. There are many specifications of each type of blade; it is very important that the correct specification be used for the particular material to be cut.

Abrasive blades (wet and dry) vary in price according to the quantity purchased:

Quantity Prices on Wet or Dry Abrasive Blades

Size		1-9	10-19	20-49	50-99	100-249	250 up
12"x⅛"x1"	each	$4.36	$3.31	$3.00	$2.79	$2.66	$2.5
14"x⅛"x1"	each	5.70	4.34	3.94	3.65	3.48	3.3
18"x⅛"x1"	each	9.89	7.52	6.83	6.33	6.04	5.8

Quantity Prices on Blue Bond Safety Blades

Size		1-9	10-19	20-49	50-99	100-249	250 u
12"x⅛"x1"	each	$ 6.52	$ 4.95	$ 4.50	$ 4.17	$ 3.98	$ 3.8
14"x⅛"x1"	each	8.34	6.34	5.76	5.33	5.09	4.9
18"x⅛"x1"	each	13.34	10.13	9.21	8.54	8.14	7.8
20"x5/32"x1"	each	16.92	12.86	11.68	10.84	10.32	9.9

Diamond blades for use on masonry saws vary in price fror $140.00 to $195.00 for 14" diameter blades and $245.00 to $310.0 for 18" diameter blades according to the specifications.

The cost of cutting masonry units varies greatly, dependin upon the type of material, blade specifications and upon th operator.

For instance a 2"x5"x12" double shell vitrified or cerami glazed structural facing tile can be cut completely throug (2"x5") in 17 seconds, with approximately 95 sq. in. of blad wear, or a blade cost of 2 cts. per cut. It is most important t

choose the proper blade specification from the many available. For example, when extreme speed is desired, a soft specification for that particular material should be used; conversely, if speed is not essential and blade wear cost is not a factor, then a harder specification is used.

Concrete products vary considerably in hardness, such as sand-gravel blocks compared with Haydite blocks. Therefore, blade wear and cutting time will vary accordingly. As an average, most 8"x8"x16" concrete blocks can be sliced in two in 14 to 16 seconds at a cost of less than one cent per unit.

Fire brick varies tremendously in hardness, as well as types. Ordinary dry press or silica can be cut in two very rapidly, while Super-duty refractories or Basic, Chrome and Magnesite requires 15 to 18 seconds for each cut completely through, at a cost varying from 2 to 6 cts. depending upon actual density.

All the above costs and cutting speeds are based on cross cuts. Longitudinal cuts will approximate the same for equivalent area.

The following is an example of the approximate time required making cuts in various masonry products:

Material	Type of Cut	Length of Cut	Depth of Cut	Approximate Time Required
Acid Brick	Miter	4½"	2¼"	15 seconds
Concrete Block	Straight	8 "	8 "	19 seconds
Glazed Brick-Tile	Miter	6 "	4 "	15 seconds
Magnesite Brick	Miter	2¾"	4 "	15 seconds
Rotary Kiln Block	Straight	8 "	3 "	11 seconds
Silica Brick	Straight	8 "	2¼"	10 seconds
Roofing Tile	Miter	9 "	2 "	14 seconds
Clay Sewer Pipe	Cross	4 " diam.	...	18 seconds
Concrete Cylinder	Cross	4 " diam.	...	21 seconds

Cutting Concrete with Portable Concrete Saw

Many states now specify control joints in highway paving to be cut with a concrete saw in lieu of forming for same. Advantages of this method are as follows: Improved ridability of joint; less sealing material required to seal joint; better aggregate interlock at joint; no spalling or cracking at joint which in turn reduces maintenance costs.

This same technique is also widely used for cutting floors and paving for repair work, trenches for electric conduit, pipe lines, sewers, etc., and also for scoring before breaking out concrete for machinery bases and other foundation work.

Clipper* concrete saws, designed primarily for this service,

*Norton Construction Products Division, Kansas City, Mo.

are available in several electric and gasoline powered models.

The most popular models are the 18 Hp. model C-184, the 30 Hp. model C-304, the 36 Hp. model C-374, and the 60 Hp. model C-604, all gasoline powered. Prices range from $1525.00 for the basic model C-184 manually propelled to $3255.00 for model C-604 with self propelling unit and electric starter. The water pump and spot-light are optional features on the C-604. The self propelling unit and other accessories are optional on the C-184 and C-304 models. The larger C-604 with 60 Hp. engine is generally used for sawing contraction joints in airports, highways and turnpikes. The C-304 and C-184 are widely used in patching, trenching and plant maintenance work. Electrically powered models are available from 7½ Hp. and up.

Two types of blades are used in cutting concrete with concrete saws as follows: (1) Green-Con wet-dry abrasive blades for cutting green concrete with favorable aggregate; (2) diamond blades, of various specifications, for cutting cured or old concrete.

Quantity Prices on Green-Con Abrasive Blades
All Blades 14" Diameter

Width of cut	1-9	10-19	20-49	50-99	100-249	250 up
3/16" each	$11.59	$ 9.12	$ 8.32	$ 7.73	$ 7.26	$ 6.8
1/4" each	12.64	9.66	8.87	8.28	7.81	7.4
3/8" each	16.09	12.50	11.38	10.61	9.92	9.4
7/16" each	17.22	13.55	12.23	11.40	10.76	10.1

Diamond blades for cutting concrete vary in price from $115.0 for 10" blades, $170.00 to $235.00 for 12" blades, $205.00 to $295.0 for 14", and $280.00 to $350.00 for 18" blades, according to specifications.

The cost of cutting concrete with a concrete saw varies considerably, depending on age of concrete, type of aggregate blade specification used, accessibility of work, skill of operator etc.

Assuming proper blade specification is used for the cuttin job, green concrete 24 to 48 hours old may be cut 1-inch deep a the rate of 12 to 14 lin. ft. per minute, 2-inches deep at the rat of 8 to 10 lin. ft. per minute and 3-inches deep at the rate 6 to 8 lin. ft. per minute. These rates cover only actual cuttin time. Overall production will be reduced considerably dependin on length of each individual cut, number of machine move changes in direction of cuts, etc. Blade wear for a Green-Co blade of proper specification should cost from 1 to 2 cents pe

lin. ft. of cut 1-inch deep. For a 2-inch cut, blade cost should be 1½ to 3 cents per lin. ft.; 3-inch cut, 2 to 4 cents per lin. ft.

Cutting Concrete Pavement with a Portable Concrete Saw

When cutting old or cured concrete, using a diamond blade of correct specification, cutting time may be double the amount given above for green concrete and cost of blade wear will probably run 5 to 6 times that given above.

CONTRACTOR'S HOISTING TOWERS

There are two principal methods of hoisting concrete consisting either of an ordinary wood constructed tower or a tower built-up of sectional steel tubing.

The tubular steel towers can be purchased or rented and are much more quickly erected and dismantled than a wood tower.

Wood Hoisting Towers.—Single wood hoisting towers 50′-0″ to 150′-0″ high, for hoisting brick, concrete and other building materials, are usually constructed of 4″ x 4″ or 4″ x 6″ uprights, with the necessary 2″ x 6″ cross bracing, 2″ x 4″ guides, etc. and the cost per lin. ft. in height should average as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	2.5	$.....	$.....	$6.75	$16.88
Labor	1.5	.....	.....	5.00	7.50
Labor dismantling	0.5	.....	.....	5.00	2.50
Lumber, 10 ft. b.m.		.....	.....	.17	1.70
Guys, nails, bolts, etc.		.....	.....	2.50	2.50
Cost per lin. ft.	4.5		$.....		$31.08

Double hoisting towers containing two sets of guides for two cages or one cage and a concrete hoisting bucket will cost about 25% more for labor and 50% more for material than given above.

TUBULAR HOISTING TOWERS

Tubular hoisting towers are extensively used by contractors in all parts of the country for hoisting all types of building materials and for concreting, because of the ease with which they are erected and dismantled, their great strength and stability, as well as their economy.

They have practically supplanted the wood frame hoisting tower in the construction of modern buildings.

Tubular hoisting towers are designed for handling material and concrete, with or without chuting. They are built in any height and with one or more compartments. Their many advantages both in construction and in performance, their durability and low maintenance, and their remarkable adaptability to various jobs make them ideal as low cost equipment for contractors.

A tubular hoisting tower consists of a bottom section, the necessary number of intermediate tubular sections, each 6'-6" in height, and a top section containing the cathead with sheaves.

All intermediate sections of a given type of tower are identical and the top and bottom sections can be attached to any one of them.

Tubular hoisting towers are built in two types, light and heavy and can be built with one or two compartments.

The single and double (two compartment) towers are classified as follows:

Size of legs	Heavy Type 3-in.	Light Type 2-in.
Maximum height	350' 0"*	201'-0"
Live load capacity	5,000 lbs.	3,200 lbs.
Maximum size concrete bucket	35 cu. ft.	.....

*Higher towers require special material.

The light type towers are known as class 3200 and the heavy type towers are known as class 5000.

The size of the cage platform in the single tower is 5'-10½":

A Tubular Steel Hoisting Tower, Showing Cage, Concrete Bucket, Hopper and One Type of Hoisting Boom. Installation of a Cathead Would Complete the Hoisting Mechanism.

Tubular Steel Hoisting Tower with Cage

7′-6½″. For double towers the size of one cage platform will be 5′-10½″ x 7′-6½″ and the other platform will be 5′-10″ x 7′-2″.

Erecting and Dismantling Steel Tubular Towers.—When estimating the cost of erecting and dismantling a steel tubular tower, the number of man-hours involved depends upon the height of the tower and the general conditions involved. For instance, it will take considerably longer to erect a tower 208′-0″ high than one 65′-0″ high, not only in time consumed but also in man-hours per section, taking into consideration the amount of material involved as well as the height to which the equipment must be raised.

Time given includes erection, dismantling and handling in man-hours per lin. ft. in height.

Light Type Single Tubular Towers	1-1.5 hr.
Light Type Double Tubular Towers	1.5-2 hr.
Heavy Type Single Tubular Towers	1.5-2 hr.
Heavy Type Double Tubular Towers	2-2.5 hr.

Approximate Prices of Light Duty Tubular Steel Hoist Towers

Description	Single Well	Double Well
52′-0″ tower complete with base, cage, cathead, etc.	$1400.00	$2400.00
Additional 6′-6″ sections	100.00	160.00
Landing panels	30.00	50.00

Maximum height 201′-0″, 2″ legs. Maximum live load 3,200 lbs.

Approximate Prices and Weights of Heavy Duty Tubular Steel Hoist Towers*

Description	Single	Double
65′-0 Tower, complete with base, 10 intermediate sections, guides, top, cathead, bottom sheave assembly and cage.	$2800.00	$4500.00
	8,500 lbs.	13,000 lbs.
Additional 6′-6″ sections up to 350 ft.	125.00	190.00
Landing Panels	30.00	50.00

Maximum height 350′-0″. 3″ legs, 1″ braces, 2″ girts. For higher towers special material is necessary.

Maximum live load 5,000 lbs.

On double towers, use 1 long and 1 short cathead.

Bucket, 35 cu. ft. capacity, $1050.00. Weight 1,100 lbs.

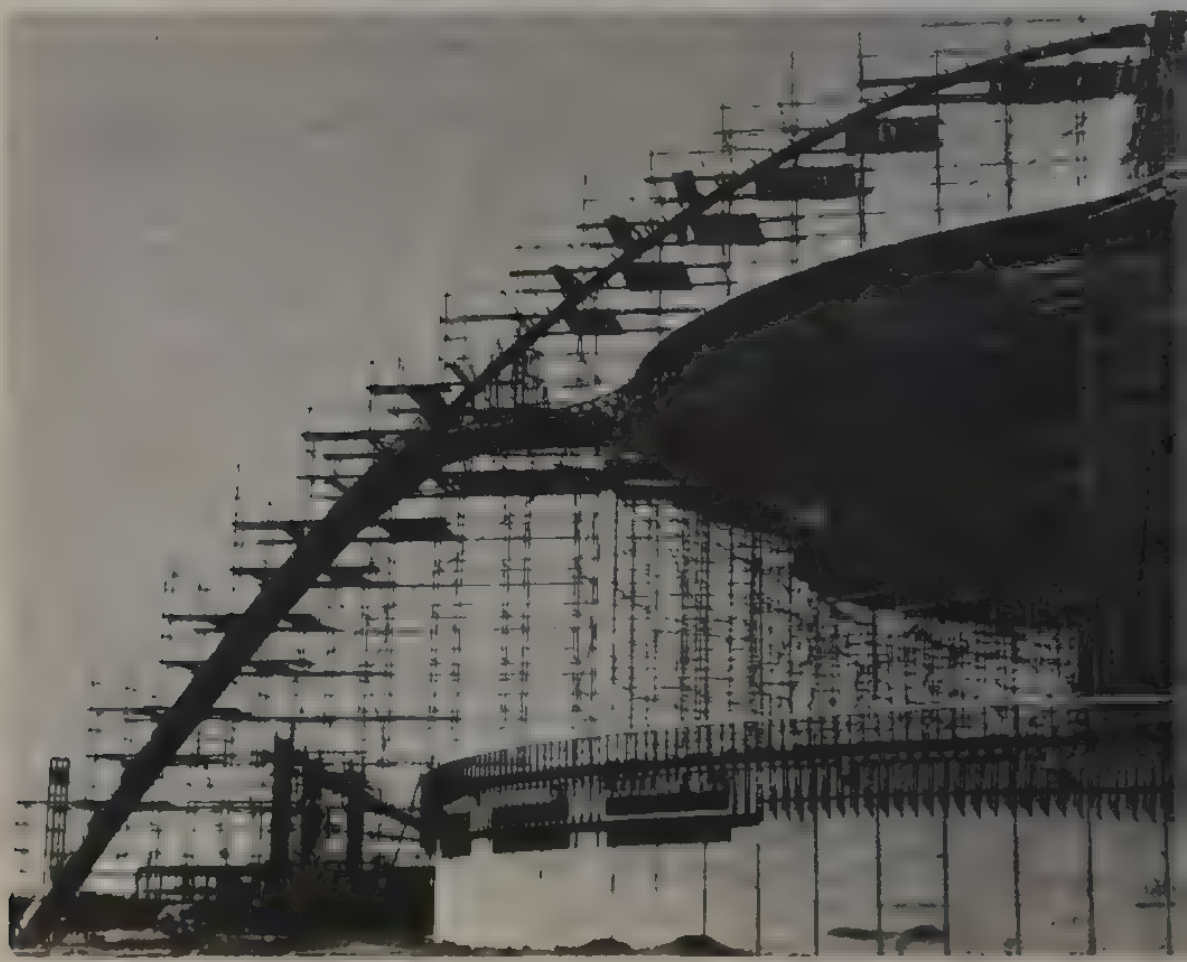
Hopper for use with above bucket, 45 cu. ft. capacity, $600.00.

Weight 780 lbs. includes dumping bar and clamps for Tower.
Floor hopper, 45 cu. ft. capacity, $425.00. Weight 1,150 lbs.

Tubular Steel Scaffolding.—The most versatile type scaffold ing is galvanized steel tubing with a male fitting on one en and a female fitting on the other to form interlocking unit These units are then coupled together with a patented couplin device. It can be adapted to a variety of uses and its simplicit has found general acceptance among the building trades. Basi ally, it consists of four parts; interlocking steel tubes of variou sizes, a base plate or caster, and an adjustable or right ang coupler. All parts are galvanized as a permanent protectio against rust and discoloration.

This galvanized carbon steel tubing or pipe is approx imately of 2" o.d. (1½" Standard Pipe) and weighs 2¾ lbs. p ft. Other sizes are 2½" o.d. (2" Standard Pipe Size) whic weighs about 3¾ lbs. per ft.

Standard lengths for tube are 6'-0", 8'-0", 10'-0", 13'-0", 16'-0 and 20'-0", and for pipe are 6'-0", 8'-0", 10'-0" and 13'-0". Othe



Tubular Steel Scaffolding for Exterior Work

sizes may be obtained but those mentioned are the sizes generally used by the building trades. Each section is fitted with a bayonet locking device.

This locking device between members is permanently affixed to the tubes, which method insures a perfectly rigid attachment which has been tested to a load of 20,000 lbs. in tension. The assembled Tube and Fittings make up a complete unit so designed as to have Flush Joints.

Standard couplers are made of drop-forged parts, except for the steel hinge pins on which the catch bolts hinge. The most widely used couplers are 2" x 2", both adjustable and standard, and 2" x 2½", both adjustable and standard, and 2½" x 2½", adjustable and standard. This type of scaffold is the most versatile of all built-up scaffolds.

Estimating costs of erecting scaffolding depend upon many conditions; the type of job to be done, whether interior or exterior; ground conditions; height and width, as well as load to be carried; and length of time it will be in use.

Approximate Rental and Sales Prices on Exterior Tubular Steel Scaffolding On a Sq. Ft. Basis

Exterior or Perimeter scaffolding work is based on the number of sq. ft. of wall area actually scaffolded.

Minimum rental period for tubular scaffolding is usually two months.

Type of Scaffolding	Light Duty	Medium Duty	Heavy Duty
Live Load per Sq. Ft. on any one Platform	25 lbs.	50 lbs.	75 lbs
Diameter of Posts	2" o.d.	2" o.d.	2½" o.d.
Maximum Load per Post, Lbs.	6,000	6,000	10,000
Post Spacing, Feet	5'x10'	5'x7'	5'x7'
Rental per Month per 100 Sq. Ft. of Wall	$ 5.00	$ 6.00	$ 7.00
Sales Price per 100 Sq. Ft. Wall Area	$100.00	$150.00	$200.00
Weight per 100 Sq. Ft. Wall Area, Lbs.	250	280	336
Erection per 100 Sq. Ft. Wall, Man-Hours †	3.0	3.5	4.0

†Labor hours includes erection, dismantling and handling in man-hours per 100 sq. ft. of wall area.

Approximate Rental and Sales Prices on Interior Tubular Steel Scaffolding On a Cubic Foot Basis

The following approximate prices are for continuous scaffol ing to fill a given cubical space. Prices are based on the nur ber of cubic feet occupied by the scaffolding.

Tubular Steel Scaffolding for Interior Work

Minimum rental period for tubular scaffolding is usually t months rent.

Type of Scaffolding	Light Duty	Medium Duty	Heavy Duty
Live Load per Sq. Ft. on any one Platform	25 lbs.	50 lbs.	75
Diameter of Posts	2" o.d.	2" o.d.	2½"
Maximum Load per Post, Lbs.	6,000	6,000	10,0
Post Spacing, Feet	6'x10'	6'x8'	6'x6
Rental per Month per 100 Cu. Ft. of Volume	$ 0.40	$ 0.45	$

Type of Scaffolding	Light Duty	Medium Duty	Heavy Duty
Approx. Sales price per 100 Cu. Ft. of Volume	$ 9.75	$ 12.00	$ 13.20
Weight per 100 Cu. Ft., Lbs.	20	23	26
Erecton per 100 Cu. Ft., Volume, Man-Hours†	0.50	0.55	0.75

†Labor hours includes erection, dismantling and handling in man-hours per 100 cu. ft. of volume.

Sectional Steel Scaffolding.—Sectional steel scaffolding or prefabricated scaffolding is readily assembled and installed and is well adapted to various kinds of building and maintenance work. Various sizes of 5′-0″ wide frame units, trusses and ladder scaffold components, make it simple to erect a suitable and a rigid, safe scaffold under any conditions.

The scaffold components are manufactured to resist corrosion and rusting. Because of their rugged construction they are not damaged during assembling or dismantling. This is a lighter type scaffold than the tube and coupler type and has an approved working height limit of approximately 125′-0″.

The tubing used in the frames and trusses is carbon steel, the higher physical properties of which affords the opportunity to reduce weight without sacrificing strength.

The sectional steel scaffolding has found wide acceptance among bricklayers, plasterers and others of the building trades because of its adaptability to rolling towers and to exterior and interior construction and maintenance.

The spacing between frames may be either 3′-0″, 5′-0″, 6′-0″, 7′-0″ or 10′-0″, and the sizes of the frames may vary from 3′-0″ to 10′-0″ in height, thereby allowing for a wide variety of uses. Braces are attached to the frames by means of wing nuts or automatic locks.

Approximate Prices of Sectional Steel Scaffolding

Bases	Price Each
Plain Bases	$ 1.30—$ 2.00
Swivel Bases	2.50— 2.75
Adjustable Swivel Bases	9.00— 12.00
End Frames	
5′-0″x5′-0″ End Frames	16.00— 20.00
6′-6″x5′-0″ End Frames	20.00— 30.00
10′-0″x5′-0″ End Frames	45.00
Guard Rails or Runners	
Guard Rails, Angles, 5′, 6′, 7′ or 10′	$ 1.50— 2.50

Pivoted Diagonal Braces	
Pivoted Cross Braces, 3'x5', 3'x6', 3'x7'	3.00— 4.00
Pivoted Cross Braces, 5'x5', 5'x6', 5'x7'	3.00— 4.00
Pivoted Cross Braces, 3'x10', 5'x10'	5.00— 6.00
Fittings	
Guard Rail Supports	3.00— 4.00
Hoist Arms	10.00— 30.00
Sidewall Brackets, 20"	6.00— 10.00
End Brackets, 20"	10.00— 15.00
Casters, 6" with Brakes, Rubber-Tired	20.00
Trusses 8'-0" to 22'-0"	25.00— 60.00

Suspended Scaffolding

The most economical method of scaffolding for masonry worl on buildings with a structural steel or reinforced concret skeleton framework is suspended scaffolding. The working plat form is supported by regularly spaced scaffolding machines each consisting of a pair of cable drum hoist mechanisms wit connecting steel putlog, suspended by steel wire rope from stee or aluminum outrigger beams anchored to roof or floor framin above.

Standard width machines accommodate a 5'-0" width of soli planking. Machines are available to accommodate 8'-0" wide deck ing to permit wheeling of material on scaffold platform Machines are also available for mechanized material handlin with the inboard cable drums set back from the wall to provid a 5'-0" wide platform for material handling traffic and stock piles on one side and a separate 20" wide working platform fo masons on the other. All machines are available with or witho steel frames to support overhead protective planking. For max imum safety, overhead planking should be used, together wit toe boards and guard rails along outer edge of platform.

Scaffolding machines are usually spaced 7'-0" apart, permi ting the use of 16'-0" scaffold plank. A ratchet device on th drum hoist mechanisms provides positive locking while sti permitting easy raising or lowering of scaffold to maintai bench-high location of work for maximum efficiency and be workmanship.

Outrigger beams are usually anchored to roof constructio 7'-0" on centers, if building is not over 150'-0" high, the max mum lift capacity of scaffolding machines. For structures e ceeding 150'-0" high, one or more additional installations w be required on lower floors. There are various methods anchoring beams to building framework, such as securing wi steel straps to anchor bolts set in concrete slabs or beam bolting to inserts set in concrete; and anchoring to beams

Sectional Steel Scaffolding

joists with U-bolts and bars through holes in concrete slabs.

Conditions affecting the installation of suspended scaffolding vary so widely it is impossible to give unit costs that will be of any value in estimating. The manufacturer and erector will

gladly quote a firm price on any specific job where this scaf folding method is applicable. This service is available nation wide.

Suspended Scaffolding for Masons

Ladder Type Scaffolding.*—For interior scaffolding, particularly for low to medium height work, ladder type scaffolds are considered very efficient. The type with horizontal bracing is most desirable for interior work because they span over furniture, machinery or equipment. Scaffolding that can be assembled without bolts or nuts can be erected or dismantled more quickly and easily. Platforms that can be adjusted for height permit men to stand at the most efficient distance from their work. This latter feature is important when scaffolding for electricians, plumbers, heating and ventilating workmen, acoustical erectors, painters, maintenance men and others doing off-the-floor jobs.

Ladder type scaffolds are sold as complete scaffold units which include two ladders, two platform support trusses and one plywood platform (exterior type plywood, metal bound). The platforms are adjustable for height every three inches. Each unit is 6′-0″ high by 6′-0″ long (or longer if desired) by 2′-5″ wide. They can be used separately or in combinations to scaffold larger areas. Casters can be furnished either with or without locks.

One of the outstanding advantages of scaffolds of this type is their maneuverability over permanent or semi-permanent objects, such as church pews, machinery or furniture. It isn't necessary to scaffold an entire room or auditorium because the scaffolds can be readily moved from place to place.

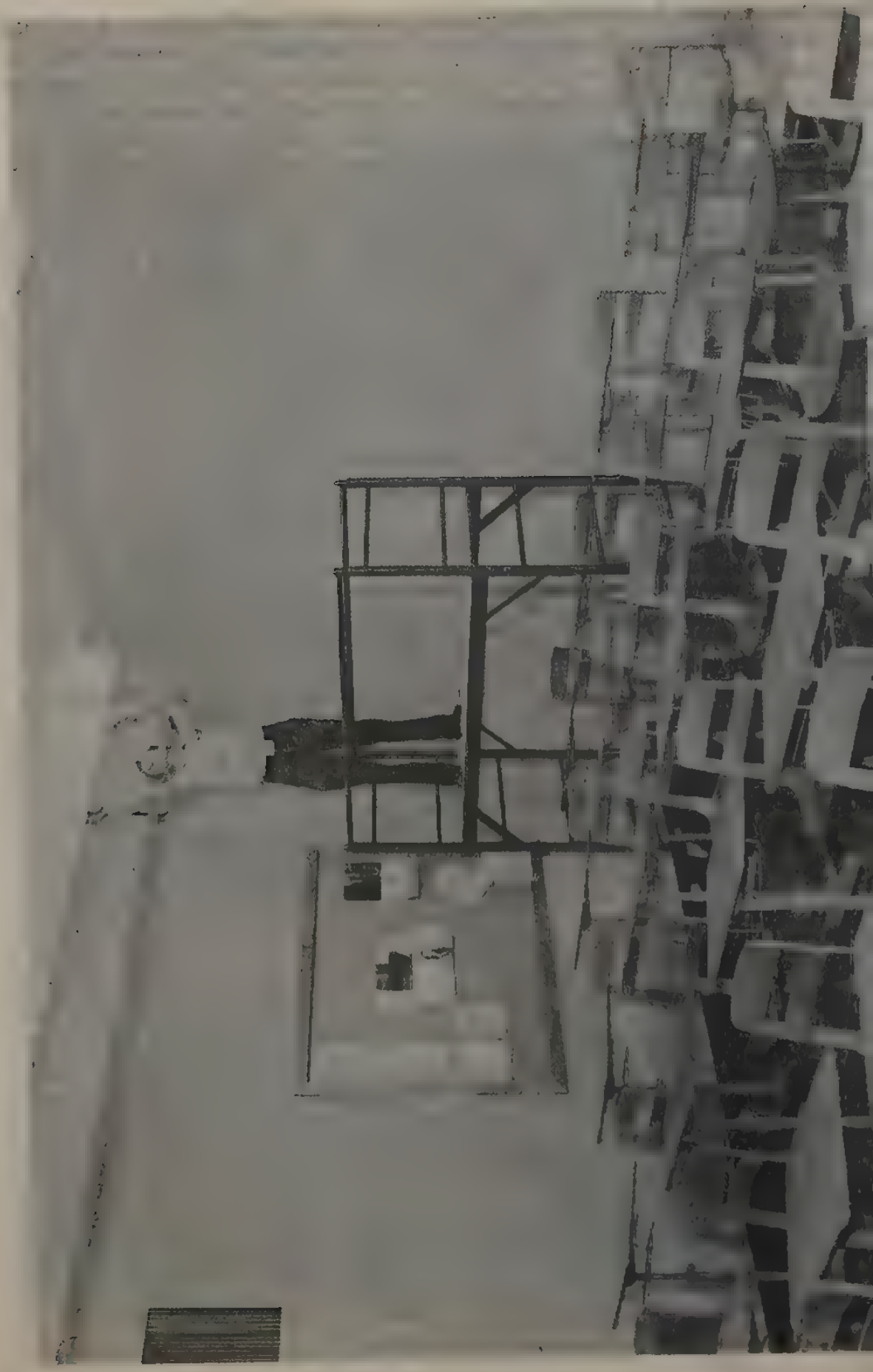
Scaffolds of this type are not rented but sell at approximately $95.00 per unit, including the platform, plus the casters.

SIDEWALK BRIDGES†

Where construction takes place adjacent to heavy traffic areas and it is impracticable to re-route sidewalk traffic into the street, a sidewalk bridge must be erected to protect the public. Rigid standards must be met in the design and erection of these structures.

Construction is as follows: 4½″ o.d. steel columns set on heavy timber mudsills support 8″ steel I-beams bridging the sidewalk. Beams are securely attached to columns by means of special steel column head castings. Columns are tied together longitudinally with two rows of pipe girts with an occasional diagonal pipe brace as required. Wood timbers, cut to a taper and set to slope towards the street, are fastened to the cross beams with U-bolts to support 6″ steel beams, spaced approximately 16″ on center, running the length of the sidewalk bridge. Two layers of 2″ or 3″ planking are then laid over the beams, the bottom layer running laterally and the top layer longitudinally. A parapet for the street side may be added if desired.

*Baker-Roos, Inc., Indianapolis, Ind.
†The Patent Scaffolding Co., Inc., Long Island City, N. Y.



Most contractors lease sidewalk bridges on an erected and dismantled basis and the supplier usually quotes a lump sum figure for a specific job. Before submitting a bid, a firm quotation covering this work should be obtained, where required.

For preliminary estimating purposes only, and average conditions, sidewalk bridges may be figured as follows:

	8′-0″ Width
Erection and dismantling, per lin. ft.	$10.00 to 20.00
Sidewalk bridge rental, per lin. ft., per month	2.50
Erect and dismantle parapet, per lin. ft.	2.50
Parapet rental, per lin. ft., per month	1.00

RENTAL OF CONTRACTOR'S EQUIPMENT

Equipment rental rates vary greatly throughout the country, depending upon local practices and conditions. They may also vary depending upon the use to which the equipment is placed; such as hard service in rocky soil or for use in sand. A compilation of rental rates, representing as nearly as can be de-

Steel Sidewalk Bridge Affords Protection to Pedestrians

termined an over-all national average of rental rates for spec fied types of equipment, is made periodically by the Associat Equipment Distributors, Oak Brook, Illinois.

This compilation is for informational purposes only and no way reflects the "going rate" in any particular area. F accurate equipment rental rate information to be used wh preparing an estimate, quotations should be obtained from l cal equipment dealers or distributors.

The following rates are taken from the 1969 edition of the abo mentioned compilation and are for those pieces of equipment mo used by contractors engaged in building construction.

Type of Equipment	Per month	Per week	Per day
Air Compressors, portable			
60 cu. ft.	$ 130.00	$ 44.50	$ 13.2
160	240.00	80.25	26.0
600 cu. ft.	858.00	293.00	98.7
Air Tools and Accessories			
Chipping hammers			
7 to 12 lbs.	37.50	13.50	4.6
Clay spades, including spade.	54.05	21.05	7.5
Paving breakers, 51 to 70 lbs...	53.25	18.75	6.0
Paving breakers, over 70 lbs...	57.25	20.00	6.4
Pneumatic pumps, heavy	111.00	38.25	12.7
Pneumatic tampers, single	42.50	16.00	5.1
Rock drills, 55 to 64 lbs.	59.50	21.25	7.0
Sheeting drivers, with sheeting head	87.25	32.40	10.4
Buckets			
Clamshell, ⅜ cu. yd.	114.00	38.50	12.7
Clamshell, 1 cu. yd.	195.00	66.75	22.2
Clamshell, 2 cu. yds.	295.00	95.25	33.7
Concrete, bottom dump, ½ cu. yd.	53.50	19.75	7.5
Concrete, bottom dump, 1 cu. yd.	80.50	29.00	10.
Dragline, ⅜ cu. yd.	80.75	27.25	9.
Dragline, 1 cu. yd.	150.00	50.75	17.
Dragline, 2 cu. yds.	247.00	84.25	28.
Concrete Buggies, power driven			
Manually guided, 12 cu. ft.	171.00	60.00	18.
Carries operator, 18 cu. ft.	216.00	73.50	22.

Type of Equipment	Per month	Per week	Per day
Clamshell Excavators, (no bucket)			
Crawler mounted			
Diesel, 30 ton*	$2,243.00	$ 778.00	$ 288.00
Diesel, 60 ton*	3,275.00	....	....
Cranes, Hydraulic—telescopic boom			
Mounted on commercial chassis with flat bed			
8,000 lb. 5 ft. radius	740.00	241.00	67.00
10,000 lb. 5 ft. radius	994.00	342.00	120.00
Dragline Excavators, (no bucket)			
Crawler mounted			
Gasoline, to 12½ ton*	1,075.00	363.00	120.00
Diesel, 30 ton*	2,062.00	708.00	259.00
Diesel, 60 ton*	3,233.00	1,100.00	....
Graders, self propelled			
Diesel engine powered			
10,001 to 16,500 lb.	650.00	217.00	70.00
22,501 to 26,000 lb.	1,070.00	359.00	110.00
Hoists			
Electric, double drum,			
47 to 57 hp.	256.00	....	....
Electric, double drum,			
92 to 112 hp.	475.00	....	....
Gasoline, double drum,			
45 to 55 hp.	240.00	84.75	27.00
Gasoline, double drum,			
90 to 110 hp.	379.00	131.00	....
Hoist Towers, tubular steel, no accessories			
Heavy duty, 3,000-lb. capacity			
Single tower, up to 25'	357.00	123.00	41.75
Each additional 10'-0" section	20.00	9.35	5.50
Extra heavy duty, 5,000-lb. capacity			
Double platform, up to 25'	458.00	142.00	53.75
Each additional 10'-0" section	24.25	10.00	4.10

*Ratings based on machine when used as a lifting crane.

Type of Equipment	Per month	Per week	Per day
Hoist Tower Accessories			
Buckets, 17 cu. ft.	$ 56.50	$ 21.75	$ 7.5
Hoppers, vertical back			
28 to 60 cu. ft.	56.00	....	...
Heaters, space			
Oil, Gas, or L.P. Gas fired			
50,000 to 100,000			
B.T.U./hr.	74.50	26.50	8.(
300,000 to 400,000			
B.T.U./hr.	148.00	52.25	17.(
500,000 to 1,000,000			
B.T.U./hr.	275.00	100.00	30.2
Lifting Cranes			
Crawler mounted			
Gasoline, 25 ton	1,513.00	488.00	165.(
Diesel, 30 ton	1,986.00	668.00	225.(
Diesel, 60 ton	3,043.00	1,006.00	329.(
Truck mounted			
Gasoline, 20 ton	1,575.00	507.00	144.(
Diesel, 35 ton	2,785.00	921.00	293.(
Diesel, 60 ton	3,502.00	1,220.00	334.(
Mixers, concrete, portable			
6 cu. ft., power charging	140.00	48.25	16.1
11 cu. ft., power charging	197.00	70.75	24..
16 cu. ft., power charging	264.00	104.00	33.(
Mixers, mortar or plaster			
2 to 4 cu. ft.	82.75	31.75	10.1
6 to 8 cu. ft.	117.00	42.25	14..
10 to 12 cu. ft.	125.00	44.00	17.1
Power Hoes-Hydraulic			
Crawler mounted			
Gasoline, ¾ cu. yd.	1,338.00	....	..
Diesel, 1 cu. yd.	2,167.00	717.00	233.(
Diesel, 2 cu. yd.	3,620.00	1,293.00	455.
Power Shovels-Hydraulic			
Crawler mounted			
Diesel, 1½ cu. yd.	1,920.00	703.00	..

Type of Equipment	Per month	Per week	Per day
Scrapers, Diesel powered			
With 2-wheeled tractor			
10 to 12 cu. yds., struck	$1,973.00	$ 700.00	$ 229.00
20 to 27 cu. yds., struck	3,445.00	1,173.00	394.00
Tractors, crawler type, with bulldozer,			
Diesel Engine			
26 to 35 drawbar hp.	661.00	222.00	....
92 to 115 drawbar hp.	1,552.00	496.00	....
201 to 256 drawbar hp.	3,019.00	985.00	....
Tractors, 4 wheel, Combination Loader & Backhoe			
Diesel Engine			
Loader ¾ cu. yd.			
Backhoe ¼ cu. yd.	748.00	236.00	77.50
Loader 1½ cu. yd.			
Backhoe ½ cu. yd.	1,094.00	374.00	136.00
Sheepsfoot rollers			
42" dia., 48" long,			
single drum	132.00	47.25	15.75
42" dia., 48" long,			
double drum	219.00	71.75	24.75
60" dia., 60" long,			
double drum	447.00	148.00	47.00

General Equipment Rental Industry Practices

It is general practice in the industry to base rates upon one shift of 8 hours per day, 40 hours per week, or 176 hours per month of a 30 consecutive day period.

The lessor usually bears the cost of repairs due to normal wear and tear on non-tractor equipment, and the lessee bears all other costs. As for tractor equipment and rubber-tired hauling equipment, the lessee usually is required to bear all costs for maintenance and repair.

The equipment rented should be delivered to the lessee in good operating condition, and is expected to be returned to the lessor in the same condition as delivered, less normal wear.

National average rates quoted above are f.o.b. the lessor's warehouse or shipping point. The lessee pays all freight or drayage charges from shipping point to destination and return. Lessee also pays all charges for unloading, assembling, dismantling and loading where required.

Rentals are usually paid in advance and subject to the terms and conditions of the lessor's rental contract. Rates given above do not include insurance, license fees, sales taxes or use taxes.

ABOUT THE COMPILATION OF NATIONAL AVERAGED RENTAL RATES

Important

WHAT IT IS NOT: IT IS NOT A SUGGESTED RENTAL RATE BOOK. It does not establish maximum or minimum levels for rental rates and the rates are not typical for any one section of the country. For a fact it has been established that under certain conditions some of the NATIONAL AVERAGE rates shown in this publication can be unprofitable to the lessor.

It makes no better sense for a distributor to rent, or for a contractor to expect to rent, construction equipment on the basis of average national statistics drawn from reports of distributors in various parts of the country than for a contractor to bid jobs on the basis of average published bid prices on similar jobs in various parts of the country.

WHAT IT IS: This is a publication of NATIONAL AVERAGE rental rates compiled from thousands of rental charges reported by A.E.D. member equipment distributors throughout the United States. **Canadian** rental rates are *not* reflected in this publication. The figures shown are purely statistical averages—no more—no less.

The rental figures in this compilation, in addition to being NATIONAL AVERAGES, reflect an averaging of age, condition and operating efficiency of the equipment. New and practically new equipment rents for substantially more than the average reflected in this publication. As explained in the foreword of this publication, other variables also effect the rental rate in any given situation.

Caution

The rental rates and terms set forth in this compilation are for informational purposes only and not to suggest or to influence the rates or conditions of rental of any item of equipment, as this is a matter which must be determined by the lessee and the lessor of the equipment involved. Information on method of determining rental rates can be found in the foreword to "Compilation of Averaged Rental Rates for Construction Equipment."

For any distributor, or any other person, to enter into any agreement, understanding, combination or concerted action with on

or more distributors, or with one or more other persons, to adhere to the rental rates shown in this compilation, or to refrain from charging less than such rental rates, would be a violation of the federal and state anti-trust laws.

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TAXES

Old Age Pensions.—The Federal Insurance Contributions Act, F.I.C.A., requires contractors to pay a tax on all payrolls, both job and office. At the present time the employer's share of this tax amounts to 4.8 per cent of the first $7,800.00 of taxable wages paid each employee for the year.

The employer is also obliged to deduct 4.8 per cent from each employee's salary or wages but of course this portion of the tax does not increase the contractor's cost—except for the cost of additional clerical help maintaining these records. In many organizations extra employees have been required to keep these records.

Federal Unemployment Tax, F.U.T.A.—This tax is also a part of the Social Security Act and applies to all employers having 4 or more employees. However, some states have passed laws making this tax applicable to employers having one or more employees, the same as the Old Age Pension portion of the act.

This tax amounts to 3.1 per cent of the first $3,000.00 of wages paid each employee for the year, and the entire amount of the tax must be paid by the employer.

It is important that every contractor add the amount of this tax to the cost of every job estimated, otherwise if paid out of profits, it may make the profits look pretty slim.

Sales Taxes.—Many states have sales or use taxes applicable to building construction as well as to other commodities. This tax varies with the different states and there are different methods of levying same. In some states, the tax is levied on all building materials and the tax is paid by the contractor when paying for his materials, in other states the tax is applicable to the entire cost of materials entering into the construction of the building, and is paid by the contractor direct to the state. In either event, whether added to the cost of materials purchased by the contractor or whether paid by the contractor to the state, based on all or any portion of the cost of the building, the contractor should add this cost to his estimate, otherwise it will make a big dent in estimated profits.

CONTRACTOR'S INSURANCE

Contract specifications frequently require the contractor to protect the owner against loss caused by any number of contingencies. The contractor is often required to furnish bonds and insurance policies affording coverage against various types of loss.

Sound practice dictates that, regardless of contract specification requirements, consideration be given to coverage in the following categories:

Surety bond requirements, coverage for owner's property interest, coverage for contractor's own property interest, coverage for employee injuries, and coverage for injury to members of the public—both contractor's and owner's liability.

Rates on the several types and classes of coverage described below vary greatly, depending upon location, type of operations, type of structure, etc. Rates applying to each form of necessary coverage for specific projects are readily obtainable when details of the job exposure are known.

Surety Bond Requirements

The practice of requiring surety bonds on construction contracts came into being with the passage of the Heard act of 1894. This idea expanded and now, with few exceptions, all public construction must be bonded.

This plan of awarding contracts for public work and requiring surety bonds is generally known as the Bonded Competitive System, and the application of this system to public construction eliminates favoritism and gives reasonable assurance that public buildings and other works will be constructed at the lowest practicable cost.

As the law requires that contracts for public work be awarded to the lowest responsible bidder, it is necessary that competitive bids be taken. Bids are invited by advertisements and the bidder is required to submit with his bid a certified check, usually for 5 per cent of the bid, or a bid bond, usually for 10 per cent of the bid. This requirement is made to insure that bids will be submitted only by qualified contractors who will not only enter into the contract but qualify for performance and payment bonds.

The bid bond guarantees that as the contract is awarded, the principal will, within a specified time, sign the contract and furnish the required performance and payment bonds. If the principal fails to furnish the required performance bond, there will be a default under the bid bond, and the damage will be the difference

between the principal's bid and that of the next higher bidder, not exceeding the penalty of the bid bond.

Surety companies generally follow the practice of authorizing a bid bond only after the performance bond on the contract has been underwritten and approved, so that there have been few defaults under bid bonds.

Performance and Payment Bond

The laws regulating the awarding of contracts for public work usually require that each contractor to whom a contract is awarded shall furnish bonds which contain two obligations. Performance to indemnify the owner against loss resulting from the failure of the contractor to complete the work in accordance with the plans and specifications; and payment to guarantee payment of all bills incurred by the contractor for labor or materials for the work.

The federal government, under the Miller act, requires that a contractor furnish two separate bonds, one for the performance and one for payment of labor and materials. Some states follow the same procedure.

The risk of the surety under the construction contract bond is that the contractor will fail in the performance of his obligation to complete the job and pay the bills for labor and materials. The underwriting procedure is designed to weigh the hazards involved against the contractor's qualifications. If the contractor's ability is deemed sufficient to warrant the assumption that he will be able to complete the work and pay the bills, the application is approved. If not, it is declined.

Some of the most common causes of failure on the part of construction contractors which are unforeseen price rises are abnormal labor costs, fire or other loss not adequately covered by insurance, unforeseen restriction or withdrawal of credit, weather or sub-service conditions which increase the cost but not the contract price, over extension beyond the contractor's financial capacity, unavailability of materials, failure of subcontractors, death or disability of key men in the contractor's organization, a poor accident record, diversion of funds from one job to pay off overdue accounts on other jobs, inexperience in the type of work involved or dishonesty on the part of the contractor's employees.

Experience shows that one or more of these common hazards in the construction industry combine to assume extraordinary importance, especially during periods of fluctuating prices or when the economy is off-balance.

Contractors also have need of various license and permit bonds which are required by law or ordinance as a condition precedent

to the granting of a license to engage in a particular business, o a permit to exercise a particular privilege. These include license granted by federal, state, county or municipal government. Thes bonds fall into the three classes: credit guarantees, financial guar antees or indemnity bonds.

Property Insurance

If provision is not made in the specifications that fire insuranc will be carried by the owner during construction, it is importan that the contractor protect his interests by carrying some type o builders' risk insurance. This is normally written on a standar fire policy together with an extended coverage endorsement whic extends the fire and lightning provisions of the standard fire polic to include windstorm, hail, explosion, riot, smoke damage an damage from aircraft and vehicles.

An additional endorsement, vandalism and malicious mischie may be obtained. Some companies afford a broader coverage o an all risk nature although there are a number of exclusions.

There are two common builders' risk forms that may be written

Builders' risk reporting form: This form affords coverage fo the contractor from the time material is placed on the job sit until the building is completed. Under this form the contracto reports to the insurance company the actual value of the buildin at the end of each month as construction progresses and pays premium each month on the additional values that go into th building.

Completed value builders' risk form: This form of coverag today is normally preferred by a contractor as it gives him 10 per cent coverage without the necessity of keeping records as t the value of the building as it progresses or the necessity to repor at the end of each month.

This form is written for the completed value of the building The normal rate charged is about 55 per cent of the rate on th basis that at the beginning of the job there is little value and a the end you have the full value. Normally the premium under th two types of policies is remarkably close.

The interests of a general contractor can be covered and h may exclude or include the interests of subcontractors who als may be employed in the construction of the building.

Temporary structures, tools and equipment belonging to th contractor and on the premises of the building site may also b included in the coverage for the hazards insured.

Costs of such insurance vary by location, type of constructio

and available public fire protection and may be obtained from your insurance man locally.

Contractors equipment floater: Many contractors possess many thousands of dollars in contracting machinery and equipment. To properly protect these values such equipment and machinery is usually insured under a contractors' equipment floater policy.

Insurance under this form is quite flexible so that many situations may be insured to fit the contractor's particular needs. The insurance is normally written on a named peril policy which includes loss or damage by fire or lightning, explosion, windstorm, flood, earthquake, collapse of bridges and culverts, theft, landslide, collision and upset. Or if desired, a policy may be issued protecting from practically all risks of physical loss or damage. Such contracts usually write a deductible clause.

Installation Floater: the contractor who specializes in plumbing, heating, air conditioning or electrical equipment may find an installation floater more suitable to his needs. This type of policy may be written for an individual job or may be written to cover all the jobs he may secure during a year's time.

Coverage may be on a so-called "named peril" policy usually including the hazards of transportation of his material to the job site and covering fire and lightning, windstorm and hail, explosion, riot and civil commotion, smoke damage and aircraft and vehicle damage at the job site. He may also include coverage for vandalism and theft if desired.

Coverage for Employee Injuries

In most states it is a statutory requirement that workmen's compensation insurance be carried. This insurance provides the contractor's employees with the benefits specified by the various state and federal compensation laws in the event of injury or death arising out of the employment.

Most compensation acts contain at least some provisions specifying benefits for the most common occupational diseases.

Benefits vary widely between the several states. In those states where medical benefits are limited, it is advisable to carry full or extra-legal medical coverage.

Certain compensation laws are restricted and provide benefits for only specified occupations. The workmen's compensation policy may be broadened to voluntarily pay compensation to employees injured in other occupations.

In addition to providing the statutory benefits, the standard workmen's compensation policy affords employer's liability insurance against claims for bodily injury or disease arising out of

employment in the states named in the policy. This coverage against liability not within the scope of the compensation law is subject to $25,000 standard limit which can be increased for a moderate premium charge.

An injured employee or his dependents, in the event of death, generally have the right of choosing the benefits of the state where the accident occurred or the state where the employee was hired. In addition, a number of states impose penalties upon an employer who, although subject to the compensation act, has failed to provide insurance coverage. Accordingly, it is important that you discuss these points with your insurance representative before entering a state not covered by your policy and before hiring anyone in such other state.

Coverage for Injury to Members of the Public

Protection against liability for bodily injury to a member of the public arising out of the contractor's operations and against property damage liability can be afforded under either a schedule general liability form policy or a comprehensive general liability policy form.

Under the schedule form, the several hazards to be insured are specifically named and the coverage may be applied either to specified locations and operations or to all operations of the insured contractor. The comprehensive form is broader in nature and covers all the usual hazards of a general liability nature other than those specifically excluded.

Under either form, consideration should be given to at least the lines of coverage briefly outlined below:

Owners, landlords and tenants, premises exposure. This hazard includes such exposures as offices, warehouses and fixed locations in contrast to specific contracting operations as such. The usual rating basis is a charge per 100 sq. ft. of area and in the case of the usual contractor, the premium for this hazard is relatively minor compared to that for the operations hazard.

Products Liability. Completed operations coverage applying to accidents which occur after the contractor's operations have been completed. Rates per $1,000 of receipts or contract price vary over a wide range according to the operations being conducted. These rates are frequently the subject of individual account rate determination rather than the application of any base Manual rates.

Owners protective. Covering the liability of the owner for injuries to the public arising out of operations of independent contractors. Characteristic rates for general construction operations

in most states are .018 bodily injury and .011 property damage per $100 of contract cost. These rates apply to the first $500,000 of cost on each specific project. Corresponding rates for the next $500,000 of contract price are .009 and .006; for contract cost over $1,000,000—.002 and .002. Rates in Illinois and New York are somewhat higher.

Contractors' protective. Covering liability of the contractor for injuries to the public arising out of operations of subcontractors. Rating basis and rate levels stated above for owners' protective are applicable under this line to sublet contract costs.

Additional features can be incorporated into the general liability policy either for application on an individual exposure basis or to be applied on an automatic or blanket basis.

Contractual coverage. Applying to the liability of others assumed by the contractor. Rates depend on the nature of exposure and degree of liability assumed.

Accident defined coverage. Broadening the coverage to apply to continuous or repeated exposure giving rise to injury or damage in contrast to the "caused by accident" basis on which most General Liability Policies are written. Cost is usually expressed as a percentage of policy premium.

Personal injury coverage. Broadening the usual "bodily injury" nature to include such personal injury as libel, slander, false arrest, malicious prosecution, etc. Pricing varies with the degree of exposure and extent of coverage afforded.

Malpractice coverage. Covering contractor for liability arising out of error or mistake in professional treatment in on-the-job hospital or medical facilities under his control. This line is individually rated.

Increased limits of liability. The general liability rates referred to herein and in subsequent pages are at standard limits of $5,000 per person $10,000 per accident for bodily injury and at $5,000 per accident $25,000 aggregate for property damage. The percentage increase factors for various higher limits may be secured from your insurance representative.

For each employer whose premium volume is large enough to qualify for experience rating (generally $100 annual premium at basic limits but substantially higher in Louisiana, New York and Texas) the general liability rates are subject to an experience credit or debit modification computed on the past experience of that employer.

A common modification generally applies on an interstate basis except that intrastate modifications are calculated separately for New York, Louisiana and Texas.

While those three states use a separate plan in deriving experience modifications, nevertheless an employer's countrywide exposure and losses are used in even those separate state calculations.

Automobile liability coverage. Bodily injury and property damage coverage for owned vehicles, non-owned vehicles, hired vehicles or independent contractor's may be secured under a schedule form or a comprehensive form of automobile liability policy. Coverage can be selected either on the basis of a listing of owned automobiles or on an automatic basis whereby coverage applies to all owned vehicles. The rating basis for owned vehicles is based on size and weight, usage of the vehicle and geographical territory involved.

Physical damage coverage (fire, theft and collision) on owned vehicles may be afforded either under the same policy which affords automobile liability coverage or as a separate policy.

For each employer whose exposure is large enough to qualify for experience rating (generally five or more private passenger or commercial vehicles but coupled with premium volume qualification requirements in the states of Louisiana, Massachusetts, New York, North Carolina, Texas and Virginia) automobile liability rates are subject to an experience debit or credit modification computed on the past experience of that employer.

A common modification can generally apply, Massachusetts being the only state which cannot under any circumstances be combined with other states for such rating.

Disaster Relief Insurance. This is a special form of liability insurance available to contractors who may participate in the disaster relief program of the Associated General Contractors of America, Inc.

It affords bodily injury and property damage liability coverage beyond the scope of standard General Liability policies under normal conditions and applies to the use of the contractor's equipment and manpower during the emergency phase of a civil disaster or impending disaster. Details of this coverage are available through your insurance representative.

ESTIMATING THE COST OF WORKMEN'S COMPENSATION AND PUBLIC LIABILITY INSURANCE

The general insurance rates in the following table are representative rates to be used as a guide only. They are basic manua rates per $100.00 payroll, applicable to each job classification Rates and experience modifications are subject to frequent anc

sometimes radical changes and should be verified with an insurance representative for each specific project.

Major job classifications are listed in the table below. Consult your insurance representative for specific classifications.

General Workmen's Compensation and Public Liability Insurance Base Rates

Job Classification	Approximate Percent Rates	
	Range	Average
Excavation, Grading, Backfilling, etc.	2 - 16	6
Piles, Caissons, Foundations	4 - 16	10
Concrete	1 - 13	5
Masonry	1 - 7	3
Carpentry and Millwork	1 - 10	4
Lathing and Plastering	1 - 7	3
Painting and Decorating	2 - 8	3
Sash and Glazing	1 - 8	4
Roofing	3 - 28	9
Acoustical Ceilings	1 - 10	4
Siding - Metal or Composition	6 - 40	12
Marble, Slate, Tile	1 - 4	2
Doors and Hardware	1 - 5	3
Structural Steel	4 - 20	12
Miscellaneous Metals	2 - 5	3
Electric and Hydraulic Elevators	-----	5
Heating, Ventilating and Air Conditioning	1 - 5	3
Plumbing and Sewerage	1 - 3	2
Sprinklers	1 - 3	2
Electrical	1 - 5	2

Notes for this table: The rates given in this table represent approximate nationwide average rates. Each state has its own rate for each job classification which should be checked out prior to submitting a proposal. For preliminary estimating purposes, a composite average would run from 4 to 6 percent of the cost of the labor.

Supplementary Rating Plan

Reference has been made herein to base or manual rates and to experience modification of the manual rates or premium. A program of Retrospective Rating is available on an optional basis. This rating plan, superimposed on experience rated premiums is usually attractive and appropriate to the larger contractors.

Subject to certain state limitations as to combinations permissible, it is available on an intrastate or interstate basis for Workmen's Compensation and the Liability lines either separately or in combination.

Your insurance representative will be glad to explain the details of this rating plan as well as any other features of coverage or rating on these various lines of insurance.

CHAPTER V

EXCAVATING AND BACKFILLING, CAISSONS, SHEET PILING, WOOD AND CONCRETE PILES

It is not a difficult matter to compute the number of cu. yds. of earth to be excavated or removed from the premises on a specific project, but it is quite another matter to estimate the actual cost of performing this work, because of the many unknown items entering into the cost. This includes such items as type of soil, whether or not water will be encountered, pumping, whether the banks of the excavated portion will be self-supporting or whether it will be necessary to brace and sheet them, disposal of excavated earth, length of haul to dump, etc.

Estimating Quantities of Excavation.—Excavating is measured by the cu. yd. containing 27 cu. ft.

Clearing Site.—Clearing the site should be considered before figuring actual excavation quantities. This includes trees to be cut down, stumps to be removed, brush to be removed, sheds and other structures to be wrecked, etc. These operations are almost negligible if the obstructions to be removed can be handled with power equipment. If, however, this work must be done by hand it is a costly item and each operation must be carefully considered.

Some estimators list all the obstructions to be removed and price them individually while others from long experience make a lump sum allowance for this work. Needless to say the first method is the more accurate.

Stripping and Storing Top Soil.—Following site clearing, the first item usually considered is stripping top soil. Top soil is generally specified to be stripped from all areas of the site to be occupied by structures, paving, walks, etc., and to be stockpiled for later use in finish grading. To compute the quantity of top soil to be removed take the outside dimensions of the building and add an amount necessary to clear the top line of slope for

general excavation to each dimension. Usually 5'-0" each side will be sufficient. The product of these dimensions multiplied by the depth of the top soil will give the amount of top soil to be stripped and stockpiled.

In the case of paving and walks, 1'-0" is usually added to each side to obtain a width of cut which will give sufficient clearance for placing and removing forms, etc. In some instances specifications also call for top soil to be stripped from areas which are to have radical contour changes before performing the excavation and/or filling required.

General or Mass Excavation.—The next item to be considered is the general or mass excavation for basements, mat footings and other large areas to be excavated.

When computing the cubical contents of any basement or portion to be excavated take all measurements from outside face of wall footings and add 6" to 1'-0" on each side to allow for placing and removing forms and then allow for sloping the banks so they will stand reasonably stable without being supported by bracing sheet piling, etc. The amount of slope necessary to provide a "safe" hole will vary with the kind of soil to be excavated, depth of excavation, etc. Digging in previously undisturbed materia and assuming that no water or unstable conditions exist mos estimators, when taking off quantities for excavation, use a 1 : slope, that is one horizontal to one vertical, for sand and gravel a 1 : 2 slope for ordinary clay and a 1 : 3 or 1 : 4 slope for stif clay.

In some cases job conditions may not permit the sloping o banks and then it is usually necessary to sheet and brace the bank to prevent accidents from occurring resulting in damage to ad joining property and injury to workmen on the job.

On jobs having column footings which project beyond the wal footings, additional cuts must be made into the banks at th column locations to accommodate the additional width of th footings and the volume of this cut is computed by taking th column footing length plus 1'-0" or 2'-0" for work space plu "layback" of banks on both ends and multiplying by the amoun of projection beyond the wall footing to obtain the area of th additional cut, which is then multiplied by the depth of the cu to obtain the volume of additional excavation required.

The depth of the general cut is usually taken from the under side of the topsoil, previously removed, to the underside of th floor slab. Where sand, cinders or other filling material is to b placed under the concrete floor the depth should be taken to th underside of the filling material.

Example: Assume you are figuring the general or mass exca vation for a building 100'-0" x 100'-0" at grade. The wall footing

extend 6″ beyond the face of the foundation walls and on each side there are 6 column footings which are 6′-0″ long and project 2′-0″ beyond the face of the wall footings. Also assume the depth of the excavation to be 8′-0″ and that the soil will stand at a slope of 1 : 2 (one horizontal to two vertical). The volume of the excavation should be figured as follows:

100′-0″ building length plus 2 x 0′-6″ for wall footings plus 2 x 0′-6″ for work space plus an average of 4′-0″ for slope equals a length of 106′-0″. Since the building is square the main volume would be 106′-0″ x 106′-0″ x 8′-0″ or 89,888 cu. ft.

For the 24 column footings which project beyond the wall footings, the length of each additional cut would be the 6′-0″ footing length plus 2 x 0′-6″ for work space plus an average of 4′-0″ for slope or 11′-0″ and the width of each cut would be the 2′-0″ projection. Therefore the additional excavation required to accommodate the column footing projections would be 24 x 11′-0″ x 2′-0″ x 8′-0″ or 4,224 cu. ft.

The total volume required to be excavated would then be 89,888 cu. ft. plus 4,224 cu. ft. equals 94,112 cu. ft. or 3,486 cu. yds.

In some cases a portion of or the entire building site may be high and require a grading cut to produce the required contours. In these instances the grading cut should be figured first and the general or mass excavation computed afterwards taking the depth from the underside of the grading cut to the bottom of the floor slab or fill under the floor.

Trench and Pit Excavation.—To complete the building excavation quantity take-off, there are usually additional items of excavation to figure for footings, foundations, pits, trenches, etc., which extend below the level of the general or mass excavation, or which occur in unexcavated areas. This kind of excavation is always estimated separately from the general work as it is usually a more expensive operation.

In many instances a good portion of this work may be done with power equipment, with some handwork required to clean out corners and grade the bottoms. On the other hand there may be portions of the work which must be done entirely by hand and which would be much more costly than machine work. In view of the wide variance in unit cost between machine work and handwork, the estimator should decide, when he is taking off the quantities, into which category each portion of the work will fall and list the machine work separately from the handwork so that each may be properly priced.

Quantities for this work are measured and listed in the same manner as for general excavation, except the slope factor may usually be ignored, unless the additional depth exceeds 4′-0″ or if the ground will not stand safely for this depth with

vertical banks. Under these conditions, allowances for sloping the banks should be made in the same manner as for general excavation.

Backfill.—After all excavating items have been figured the amount of backfill should be computed.

An easy method of doing this is by computing the displacement volume of the construction which is to be built within the limits of the excavation, that is, the volume of footings, piers, the basement volume figured from the underside of the fill under the floor to the elevation of the top of the general cut, etc., and deducting this volume from the sum of the general or mass excavation and the trench and pit excavation. The remainder is the volume of backfill required.

Another method of figuring backfill, usually more difficult than the one previously described, is that of computing the volume from the actual dimensions of the spaces requiring backfill.

Some specifications require interior backfills to be made with sand, gravel, slag, etc., while the exterior backfill may be excavated material. In this case it is necessary to keep the two items separate as the interior backfill material will probably have to be purchased and brought in from outside sources.

On high class work backfill very often is specified to be compacted by mechanical tampers and in the case of government work, etc., a degree of compaction is also specified. In these instances the backfill operations must be considered very carefully as this is expensive work.

Excavation and Fill for New Site Grades.—Excavation and/or filling for new site grades, including cuts and fills for drives, walks, parking areas, etc., vary from simple to complex according to the site ground conditions. Estimating quantities for this work may be rather difficult and some surveying or engineering knowledge will greatly help at this point.

A number of methods are available for determining the volumes of cut and fill required and the method which is most adaptable to the particular problem will have to be chosen by the estimator after considering the problem as to the information given and the accuracy of same.

Cross Sectional Method

One of the easiest and most frequently used methods of computing grading cuts and fills when the plot plan shows both original and proposed contours is that of gridding or dividing up the area to be graded into squares, rectangles, triangles or combinations of these figures, of regular and convenient dimensions, thus forming a series of truncated prisms. The depths of cut or fill at the corners of these prisms are computed and the volume of each prism may be determined by averaging these depths and multi-

plying the average by the cross sectional area of the prism. The results of these computations are totaled, keeping the cuts separate from the fills, and the total excavation and/or fill required is obtained.

Example: Assume the contour sketch shown on the next page to be a 400.0′ x 200.0′ portion of a site grading plan showing both present and proposed contour lines. Since both the present and proposed surfaces have fairly regular slopes, as indicated by the even spacing of contour lines, a grid spacing of 50 feet in both directions has been chosen and grid lines drawn as shown, labeled alphabetically for the vertical lines and numerically for the horizontal lines.

The next operation is to figure the present ground elevation for each grid line intersection by interpolating between the present contour lines. The results are marked on the drawing in the upper right quadrant of each respective intersection.

Following this, the proposed ground elevations are similarly figured for each intersection, interpolating between the proposed contour lines and entering the results in the upper left quadrant of each respective intersection.

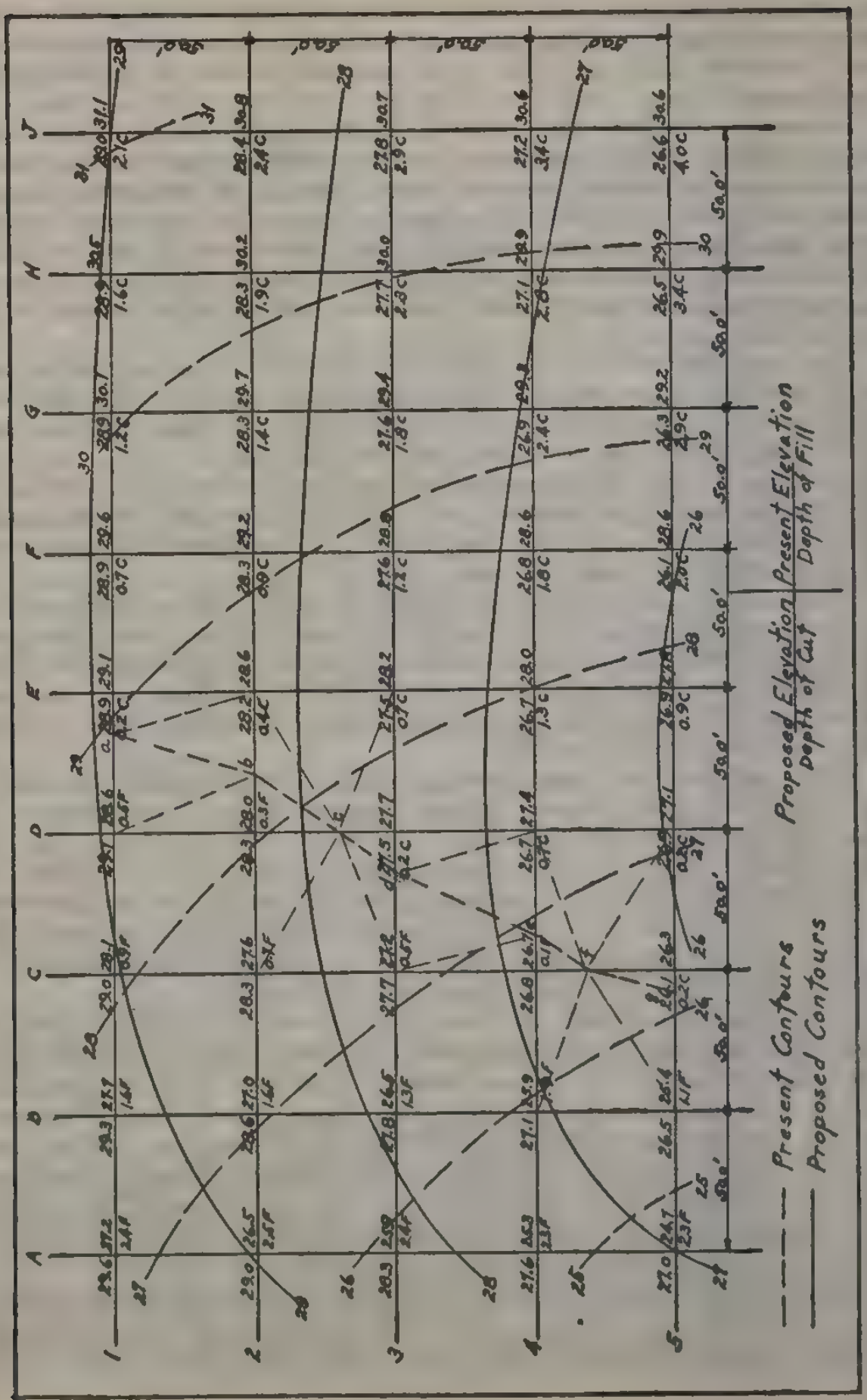
When this is completed the depth of cut or fill at each intersection can be readily determined by subtracting one elevation from the other and noting whether a cut or fill is required. This determination should be made for each intersection and the results entered in the proper quadrant, using the lower left for cuts and the lower right for fills.

When all intersections have a depth value entered for either cut or fill the plan should be examined closely to see where the grading operation will change from cut to fill or vice versa. In the sketch it will be seen that advancing from left to right on horizontal grid line "1" a change from fill to cut occurs between vertical grid lines "D" and "E" and by interpolating between the fill and cut depths the zero point "a" can be established approximately 36 feet to the right of intersection "D-1."

Similarly zero points "b, d, e and g" are established on the horizontal grid lines and zero points "c and f" on the vertical grid lines. These points are then connected by a line "a, d, c, d, e, f, g" and for all practical purposes it may be assumed that all points on this line are at the proposed elevation and require neither cut nor fill. In this case the line forms the boundary between cuts and fills. The change from cut to fill and vice versa could, of course, occur many times in actual problems depending on the irregularity of the present and/or proposed contour lines.

After the previously described operations have been completed, the actual volume of cut and/or fill required can be computed.

The volume of cut or fill in each truncated prism in the grid



Method of Cross Sectioning a Contour Plan.

system is obtained by averaging the corner depth values of each prism and multiplying by its cross sectional area. Thus for the square prism "A-1, B-1, B-2, A-2" the volume of fill would be $\frac{1}{4}$ x (2.4′+1.6′+1.6′+2.5′) x 50.0′ x 50.0′ or 5,063 cu. ft. All grid prisms are similarly treated, keeping cut and fill results separated, except those prisms through which the zero line passes. Therefore for square prism "D-1, E-1, E-2, D-2" it will be seen that this volume has been divided into two trapezoidal prisms "D-1, a, b, D-2" and "a, E-1, E-2, b." To compute the respective fill and cut volumes of these prisms they must be divided into triangular prisms first and then the corner depths may be averaged and multiplied by their respective cross sectional areas. Thus for the triangular prism "D-1, a, b" the volume of fill would be $\frac{1}{3}$ x (0.5′+0.0′+0.0′) x $\frac{1}{2}$ x 50.0′ x 36.0′ or 150 cu. ft. Similarly, the volume of fill for the triangular prism "D-1, b, D-2" would be $\frac{1}{3}$ x (0.5′+0.0′+0.3′) x $\frac{1}{2}$ x 50.0′ x 21.0′ or 140 cu. ft. The volume of cut required for the trapezoidal prism "a, E-1, E-2, b" is figured in the same manner. In the case of square cross section "C-2, D-2, D-3, C-3" it will be seen that the zero line crosses one corner of the square and divides it into a triangle "c, D-3, d" and a five-sided figure "C-2, D-2, c, d, C-3." The five-sided figure should be further divided into three triangles "C-2, D-2, c," "C-2, c, C-3" and "C-3, c, d" and the volumes of fill for each triangular prism would be as follows:

$\frac{1}{3}$ x (0.7′+0.3′+0.0′) x $\frac{1}{2}$ x 50.0′ x 30.0′ or 53 cu. ft.
$\frac{1}{3}$ x (0.7′+0.0′+0.5′) x $\frac{1}{2}$ x 50.0′ x 50.0′ or 146 cu. ft.
$\frac{1}{3}$ x (0.5′+0.0′+0.0′) x $\frac{1}{2}$ x 36.0′ x 20.0′ or 60 cu. ft.

When there are several prisms with the same cross section to be either cut or filled the volume of such can be computed as one solid by assembling them as follows: Multiply each corner depth by the number of typical prisms in which it occurs and then add these results and divide by 4. This is then multiplied by the cross sectional area of one prism. For example the volume bounded by A-1, D-1, D-2, C-2, C-4, B-4, B-5, A-5, A-1 can be obtained by one computation because it is composed of a series of prisms having the same cross section. In the summation of depths, those at A-1, D-1, D-2, C-4, B-5 and A-5 are taken but once, those at B-1, C-1, C-3, A-4, A-3 and A-2 are multiplied by 2, at C-2 and B-4 the depths are multiplied by 3 and at B-2 and B-3 they are multiplied by 4. All of these values are then totaled and divided by 4 and then multiplied by the cross sectional area of one prism giving the volume of fill required.

When a volume has been computed for each grid division of the site, either individually or collectively, it is only a matter of summing up the cuts and/or fills to obtain the total excavation and/or fill required to bring the site to the proposed grades.

End Area Method

It often happens that a cut and fill operation is to be performed over a long and narrow area such as for roads, levees, ditches, etc. In this case the usual method of computing the earthwork quantities is by means of end areas.

In jobs of this sort a profile plan and a topographic plan is generally furnished to the contractor as part of the bidding documents. Using this information, sections are taken perpendicular to the longitudinal center line of the work, usually at each 100 foot station, at each radical change in either present or proposed grades and where the cut changes to fill or vice versa. These sections are plotted to scale showing the original grades as obtained from the topographic plan and the proposed grades as obtained from the profile plan and design details of the surface required. After this has been done it will be apparent that areas are enclosed by the plotted lines representing the present and proposed grades at each section and these areas should be computed.

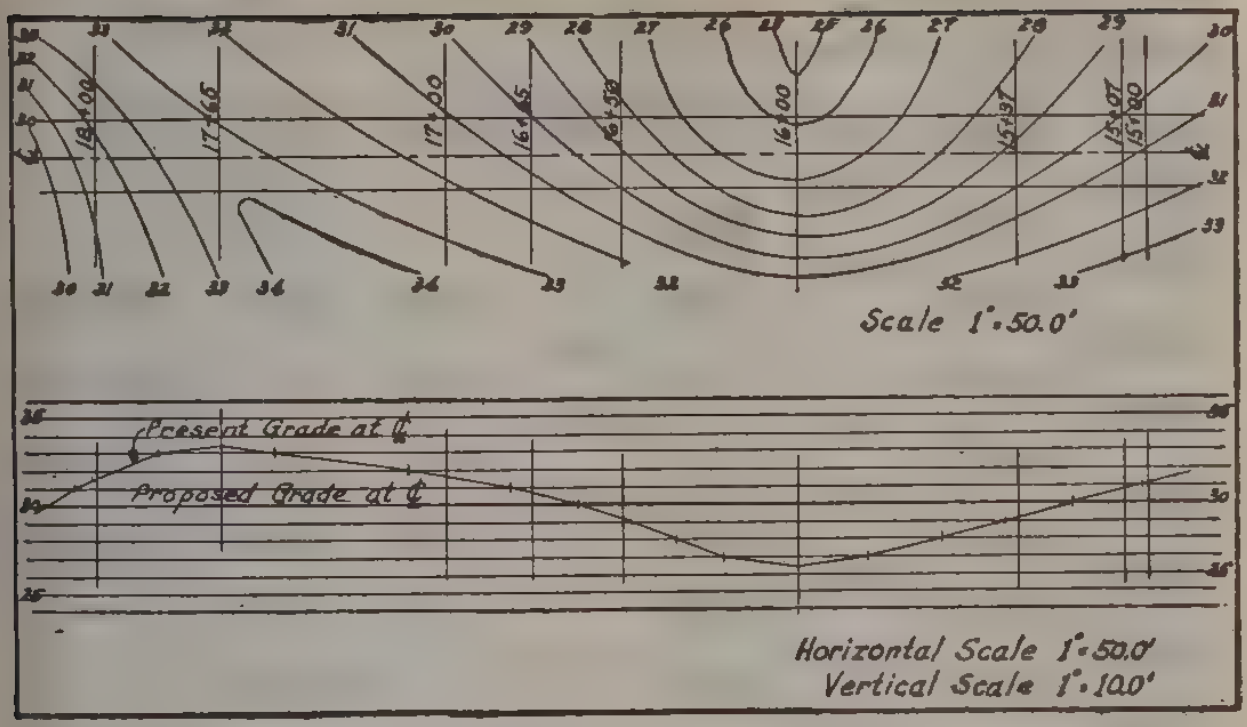
To obtain the volume of cut and/or fill between each section the usual and easiest method is to average the areas of two adjacent sections and multiply by the distance between them, keeping the cuts and fills separate. This method is not quite accurate but the results are on the safe side and in practically every case are close enough for estimating purposes.

Example: Assume the sketch on the following page to be a 300 foot portion of the topographic plan and profile plan of a proposed road location. The topographic plan shows the undulations of the present ground surface by the contours and the location of the road by the center and shoulder lines. The profile plan shows the relation between the present ground surface and the proposed road bed grade at the centerline of the road. Also assume the road bed is to be 20.0 feet wide and the shoulder slopes are to be $1\frac{1}{2}$: 1, that is $1\frac{1}{2}$ horizontal to 1 vertical.

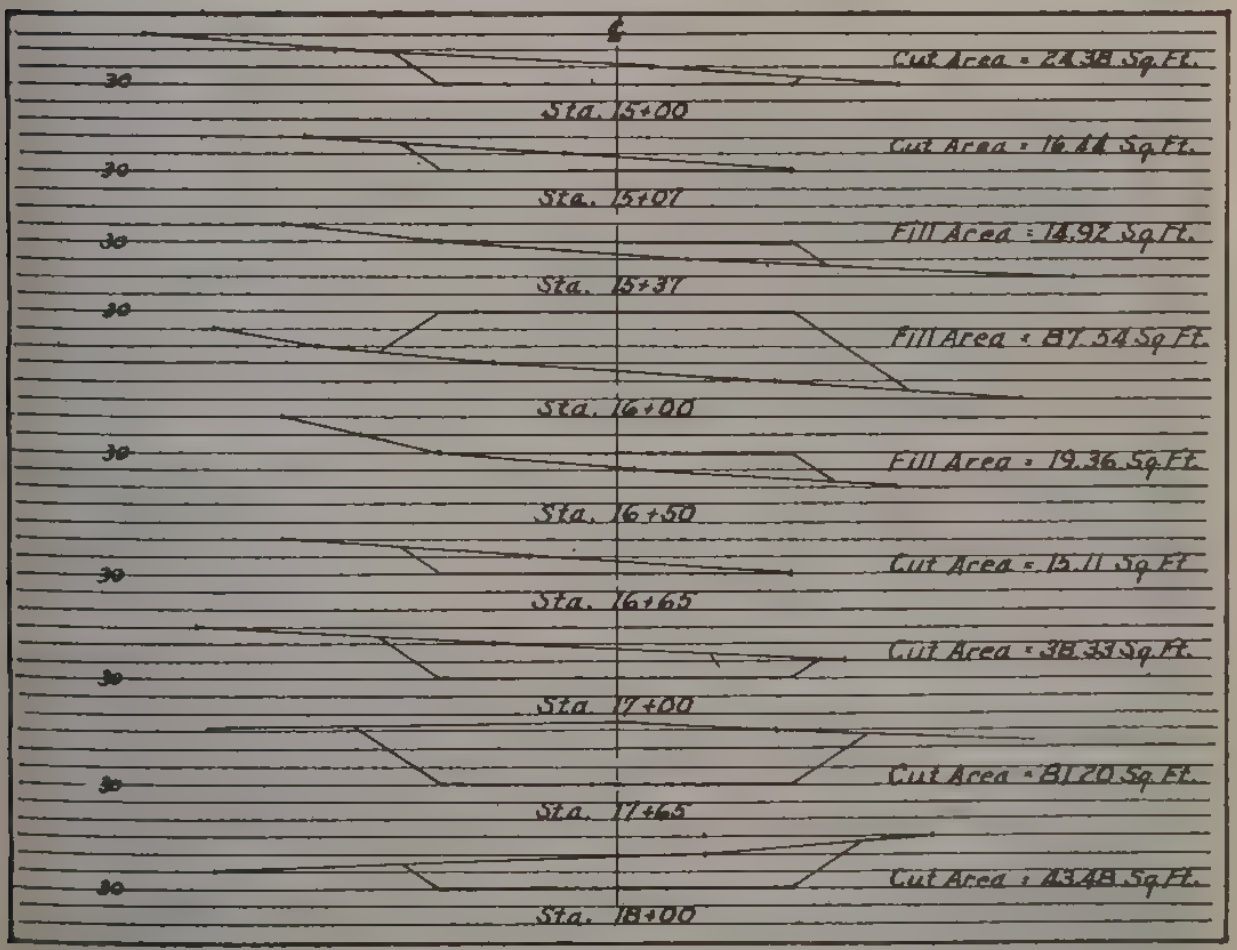
To compute the volumes of earthwork involved in this proposed grading operation, by means of the end area method, sections must be taken perpendicular to the center-line of the proposed road and the present and proposed grade lines plotted. In this case sections have been taken and plotted, as illustrated in the sketch, at even stations 15+00, 16+00, 17+00, and 18+00. Sections have also been taken at stations 15+07, 15+37, 16+50 and 16+65 because at these points the cut or fill at a shoulder of the proposed road is zero. A section is taken at station 17+65 because at this point the present grade makes a radical change in slope.

In plotting the sections any convenient scale may be used and if cross-section paper is used the job will be much easier.

As each section is plotted, the area enclosed by the present and



Topographic and Profile Plans.


Sta. 15+00
Cut Area = 24.38 Sq. Ft.
Sta. 15+07
Cut Area = 16.44 Sq. Ft.
Sta. 15+37
Fill Area = 14.92 Sq. Ft.
Sta. 16+00
Fill Area = 87.54 Sq. Ft.
Sta. 16+50
Fill Area = 19.36 Sq. Ft.
Sta. 16+65
Cut Area = 15.11 Sq. Ft.
Sta. 17+00
Cut Area = 38.33 Sq. Ft.
Sta. 17+65
Cut Area = 81.20 Sq. Ft.
Sta. 18+00
Cut Area = 43.48 Sq. Ft.

Method of Plotting End Areas.

proposed grade lines is computed and the result tabulated. Final computations are made as follows:

Station	Distance Between Stations	Area of Sections in Sq. Ft. Actual Cut	Average Cut	Actual Fill	Average Fill	Volume in Cu. Ft. Cut	Fill
15+00		24.38		—			
	7.0 ft.		20.41		—	142.87	—
15+07		16.44		—			
	30.0 ft.		8.22		7.46	246.60	223.80
15+37		—		14.92			
	63.0 ft.		—		51.23	—	3,227.49
16+00		—		87.54			
	50.0 ft.		—		53.45	—	2,672.50
16+50		—		19.36			
	15.0 ft.		7.56		9.68	113.40	145.20
16+65		15.11		—			
	35.0 ft.		26.72		—	935.20	—
17+00		38.33		—			
	65.0 ft.		59.77		—	3,885.05	—
17+65		81.20		—			
	35.0 ft.		62.34		—	2,181.90	—
18+00		43.48		—			
						7,505.02	6,268.99

If a greater degree of accuracy is required the prismoidal formula must be employed which necessitates figuring the middle area between two adjacent sections. This middle area is obtained by averaging the corresponding dimensions of both end areas and computing an area from the average dimensions; it should not be taken as the average of the two end areas. To obtain the volume between adjacent sections using the prismoidal formula, multiply the length between sections by one-sixth of the sum of the two end areas and 4 times the middle area combined.

Most specifications call for the fills to be placed in layers and then specify some degree of compaction to be attained. This should be considered by the estimator as additional equipment such as sheeps-foot rollers, pneumatic rollers, tandem rollers etc., will be required plus the labor of operation.

Rough Grading of Site.—An item for rough grading consisting of the total area cut and/or filled, less buildings, roads, walks etc., should be included in the estimate to cover the expense of dressing up the surface after the required grades have been approximately attained and preparatory to the spreading of top soil if required.

Spreading Top Soil.—In most instances the specifications call for spreading top soil over site areas not covered by other construction, usually to a depth of 6 inches. In listing this item in

the estimate usually the rough grading area multiplied by the depth of top soil indicated will give the volume required.

Finish Grading of Site.—Fine grading of top soil, usually including a hand raking operation, is generally called for and should be listed in the estimate as an item, the quantity being the area used in computing the volume of top soil to be spread.

Other Grading.—Other grading items to be considered by the estimator are the following: grading the subgrade for floor slabs, walks, paving, etc. Also some contractors include an item for grading bottoms of footings, when they are to be dug by machine, and do not include an amount for labor squaring and cleaning the holes based on the cubic yardage of footing excavation.

Disposal of Excess or Borrow.—After all excavation, backfill, grading cuts and fills, etc., have been computed and listed in the estimate, the total cuts and the total fills should be compared to determine whether there will be an excess of materials to dispose of or a deficiency of materials to be made up by borrowing or purchasing from outside sources and the results of this comparison should be listed in the estimate. The top soil comparison should be kept separate from the other materials because the cost of any top soil which must be purchased usually is much more expensive than ordinary fill material. Also any excess of top soil may find a ready market and be sold thereby reducing the overall cost of the earthwork. The difference between the cuts and fills will give the bank or compacted volume required. In the case of a deficiency of materials this compacted volume quantity must be adjusted for shrinkage due to compaction as the material will probably be bought by loose measure. In the same manner all excess bank measurement volumes must be adjusted for swell due to bulking to obtain the true volume which must be handled in the disposal operation. The amount of increase for gravels and sand is from 5 to 12 percent and for clays and loams from 10 to 30 percent.

Landscaping.—Some specifications include landscaping with excavation work but this item is usually sublet to a company specializing in this work. However, should it be necessary to include it in the excavation estimate, items should be listed for the following:

Area of seeding and fertilizing.
Area of sodding.
Number, size and species of shrubs.
Number, size and species of trees.
Allowance for maintenance for specified period.
Allowance for guarantee, if specified.

Pumping or De-watering.—Finally, careful consideration should be given to the probability of pumping or de-watering operations. In some parts of the country this is no problem whatsoever, quite

the reverse being the case. However, in most localities ground or climatic conditions make it necessary to include pumping or de-watering as an item in the estimate.

This item is quite variable, being affected by the season of the year as well as the locale. If only rainwater run-off is expected, an allowance for a few small pumps may be sufficient. If, however, the job is in close proximity to a body of water or springs are present, etc., it may be necessary to de-water part or all of the operational area by means of a well point system in which case the contractor should consult a company which specializes in this work. In any event the question should be carefully considered because a contractor can lose a lot of money in a very short time on a muddy job.

Estimating the Labor Cost of Excavation.—Before an excavating estimate is made up or a bid submitted, the estimator should visit the site and ascertain the exact conditions surrounding the work to be performed. The natural grade of the lot should be noted to compute the depth of the excavation from grade to underside of floor line; the nature of the soil should be determined, whether sand, loam, clay or rock, and whether or not water is likely to be encountered.

Water usually means an additional cost—pumping out the hole day and night until the foundations are completed. Rock usually means blasting, with a greatly increased cost for drilling, dynamiting, excavating and loading.

The safest method of determining the kind of soil is to dig a test hole the approximate depth of the basement, and from this you should obtain a fairly accurate idea of the conditions to be encountered.

If the lot is low and the basement does not cover the entire lot, part of the excavated soil may be used for filling. On the other hand, if the natural grade of the lot is above the sidewalk or established grade, it may be necessary to remove a certain amount of soil from the entire lot.

In large structures having basements and sub-basements, the excavation may extend 40 to 50 feet below grade. This requires the construction of heavy steep runways so that trucks may get in and out of the hole, also an extra truck or bulldozer may be required helping the loaded trucks out of the hole. These items must all be taken into consideration when pricing any excavating job.

If it is necessary to remove the excavated soil from the premises, locate the nearest available dump, and ascertain just how the soil may be handled at the dump, whether it is necessary to spread it, etc.

These are all items that affect the cost and should be given careful consideration by the estimator.

In most localities there are contractors who make a specialty of excavating and are familiar with the kind of soil encountered in different parts of the town. These contractors usually quote a price per cu. yd. for all of the general excavation or they may quote a lump sum for the entire job.

Trench, pier and all hand excavating is usually performed by the general contractor.

Cutting Down and Removing Trees

The cost of cutting down and removing trees will vary with their size and the method used in cutting and disposing of them. If their roots run through the portion to be excavated it will increase the labor cost of excavating and removing the soil.

The following costs are based on a gang of 3 or 4 men working together, cutting down trees by hand, removing branches and cutting the trunk into 4′-0″ lengths. Labor costs of digging down around roots and removing stump are given extra.

Approx. Diam. of Tree	Approx. Height of Tree	Labor Hours	Extra Labor Removing Stump
8″ to 12″	20′-0″ to 25′-0″	9 to 12	8
14″ to 18″	30′-0″ to 40′-0″	12 to 16	10
20″ to 24″	45′-0″ to 50′-0″	20 to 24	12

If necessary to cut trunks and stumps into small pieces and load into trucks or wagons, add extra for this work.

Where many trees are to be removed, a power or chain saw will speed the work and reduce costs considerably. A chain saw will cut within 2 to 4 inches of the ground but if the stump must be removed, this is ordinarily hand work.

Chain saws are obtainable operated by gasoline or electric power or compressed air, and with 24″, 36″, 48″ and larger saws. Cost $300.00 to $600.00.

Chain saws will cut through soft wood at the rate of 1″ in 1 to 2 seconds and through hardwood at the rate of 1″ in 2 to 4 seconds.

Chain saws usually require 2 men to operate them, although in some localities, union regulations require 3 men to each unit.

Using a chain saw with 3 men in the crew cutting trees, removing branches and cutting the trees into 2′-0″ lengths, should average as follows:

Approx. Diam. of Tree	Approx. Height of Tree	Labor Hours	Extra Labor Removing Stump
8″ to 12″	20′-0″ to 25′-0″	2½ to 3	8
14″ to 18″	30′-0″ to 40′-0″	3 to 4	10
20″ to 24″	45′-0″ to 50′-0″	5 to 6	12

A faster and more economical method of removing trees is by using a bulldozer or tractor shovel for this work.

Trees up to 15 inches diameter or trees such as pine, which have small root systems, can be rapidly up-rooted by raising the dozer blade or shovel bucket to maximum height and pushing against the tree. It may be necessary to strike the tree a few times to loosen it.

Trees with diameters of 24 inches or more, or trees like elms, maples and oaks, which have heavy, wide-flaring root systems usually require root-cutting before they can be pushed over. First make a trench-cut with the dozer blade or shovel bucket across the roots on the side opposite the direction in which the tree must be felled. Backfill the trench and form a ramp up to the trunk so the machine can strike as high on the tree as possible. Unless the tree is exceptionally large or well-rooted it can now be pushed over. If not, try cutting the roots on each side of the tree perpendicular to the first cut and, if necessary the roots on the side toward which it will be felled.

Once the tree is felled it can be pushed or dragged to a disposal area where it can be sawed into lengths for hauling or burned.

A WORD OF CAUTION—Always watch for falling limbs. In the case of pines, if the whipping action is too great, the top may snap off and kick back on to the machine or operator. Also as the tree begins to fall, the machine must be backed up quickly so that the upturning root system will not come up under the machine with the possibility of damaging the unit or hanging it up.

An experienced operator, using a medium to large size tractor, 80-Hp and up if crawler type, 160-Hp and up if rubber tired, with ground conditions affording good traction and no problems regarding steep slopes, etc., should fell trees at the following rates:

Approx. Diam. of Tree	Approx. Height of Tree	Minutes Req'd for Felling
8" to 12"	20'-0" to 25'-0"	5 to 10
15" to 24"	30'-0" to 50'-0"	15 to 20
27" to 36"	55'-0" to 75'-0"	25 to 30

Add for pushing felled trees to disposal area and labor disposing of same.

METHODS OF EXCAVATING

Excavating costs will vary with the kind of soil and the method used in loosening and removing same.

Except on very small jobs, practically all mass excavation

today is performed by power operated equipment, i.e., power shovels, cranes with dragline or clamshell buckets, bulldozers, tractor excavators, scrapers and trenching machines, while ordinary grading and backfilling is performed by bulldozers and high shovel tractor excavators.

In shallow excavations, where the excavated earth may be spread over the lot not more than 50 feet from the excavation, bulldozers or tractor shovels (a tractor equipped with a shovel that may be elevated to load directly into trucks or over the sides of the excavation) are frequently used. This type of excavator is also used for excavating basements, loading directly into trucks.

There is also a "back-digger" type of power shovel commonly called a "hoe" that is extensively used for basement excavation as it is equipped with a shovel that "pulls" toward the machine which is always located on the bank above the excavation, working from the sides and ends of the excavation.

In large excavations, the use of a regular power shovel is the most satisfactory and economical method to use. The power shovel will excavate and load the trucks as fast as they can be handled in and out of the hole and will enable the job to proceed much faster.

If it is desirable to keep the digging machine on the bank above the excavation and the depth is greater than a hoe can handle, a crane equipped with a dragline bucket is usually used.

For individual pier footings, small pits and hard-to-reach spots, a crane equipped with a clamshell bucket may be used.

On medium to large size grading jobs, self-propelled or tractor hauled scrapers are used quite often and perform cutting and filling operations very creditably.

The tables of quantities and costs given in the following table are average. It is true experienced excavators will perform more work than given in the tables but an inexperienced man will perform less, so average conditions have been used.

Hand Excavating Production and Quantities

SAND OR LOAM	Ave. No. Cu. Yds. 8-Hr. Day Per	Labor Hours Per Cu. Yd.
Shoveling and loading trucks by hand.....	8 to 10	0.90
Trenches to 5'-6" Deep	7 to 8	1.07
Pits and piers to 6'-0" Deep (1 lift).....	6.....	1.33
Pits and piers to 12'-0" Deep (2 lifts).....	6.....	2.67

Pits and piers to 18'-0" Deep (3 lifts)	6	4.00
Picking, loosening and shoveling frozen sand or loam	1 to 2	5.33
Backfilling by hand, no tamping	18 to 20	0.40
Spreading loose sand or loam by hand	35 to 40	0.21

ORDINARY SOIL

Shoveling and loading trucks by hand	5 to 6	1.375
Trenches to 5'-6" Deep	4 to 5	1.75
Pits and piers to 6'-0" Deep (1 lift)	4	2.00
Pits and piers 12'-0" Deep (2 lifts)	4	4.00
Pits and piers to 18'-0" deep (3 lifts)	4	6.00
Backfilling by hand, no tamping	16 to 18	0.47
Spreading loose soil by hand	30 to 35	0.25

HEAVY SOIL AND CLAY

Shoveling and loading trucks by hand	3½ to 4½	2.00
Trenches 5'-6" Deep	3 to 4	2.25
Pits and piers to 6'-0" Deep (1 lift)	3 to 4	2.25
Pits and piers to 12'-0" Deep (2 lifts)	3 to 4	4.50
Pits and piers to 18'-0" Deep (3 lifts)	3 to 4	6.75
Backfilling by hand, no tamping	12 to 14	0.61
Spreading loose clay by hand	23 to 27	0.32

Excavating Using a 1 Cu. Yd. Tractor Shovel

Costs Given per 100 Cu. Yds. CLASS OF WORK	Ave. No. Cu. Yds. per 8-Hr. Day	Tractor and Operator Hours
Excavating ordinary soil and placing in piles on premises	325 to 375	2.30
Excavating heavy soil and clay and placing in piles on premises	250 to 300	2.90
Loading loose sand or gravel into trucks	400 to 450	1.90
Excavating ordinary soil and loading into trucks	400 to 450	1.90
Excavating heavy soil and clay and loading into trucks	300 to 350	2.50
Backfilling loose earth—Bulldozing	500 to 600	1.45

The above table is based upon a 50-foot haul from excavation to dum
For each additional 50 feet in length of haul, add 1½ to 2 hrs. trac
time per 100 cu. yds.

Excavating Using a 2¼ Cu. Yd. Tractor Shovel

Costs Given per 100 Cu. Yds. CLASS OF WORK	Ave. No. Cu. Yds. per 8-Hr. Day	Tractor and Operator Hours
Excavating ordinary soil and placing in piles on premises	600 to 650	1.30
Excavating heavy soil and clay and placing in piles on premises	450 to 500	1.70
Loading loose sand or gravel into trucks	775 to 825	1.00
Excavating ordinary soil and loading into trucks	775 to 825	1.00
Excavating heavy soil and clay and loading into trucks	575 to 625	1.35
Backfilling loose earth—bulldozing	925 to 975	0.85

The above table is based upon a 50-foot haul from excavation to dump. For each additional 50 feet in length of haul, add ¾ to 1 hrs. tractor time per 100 cu. yds.

POWER SHOVELS AND CRANES

Estimating the Cost of Owning and Operating Power Shovels.—Much of the following information on "Estimating Cost of Ownership and Operation of Power Shovels, Hoes and Cranes" is furnished through the courtesy of the Power Crane and Shovel Association, New York.

Total Investment or Cost of Equipment.—Depreciation, interest, taxes and insurance are directly related to the initial investment in a power shovel or crane. In addition, certain other costs may be estimated by their normal relationship to this figure. Therefore, the proper determination of the total cost is a basic requirement.

The price f.o.b. factory should cover the complete machine with all variable equipment and accessories such as various attachments, light plant, magnet generator, clamshell bucket, etc.

Approximate Prices of Power Shovels, Draglines, Clamshells and Lift Cranes

The following are approximate prices, f.o.b. factory, and are given so the estimator will have some idea of the investment required in shovels and cranes of various sizes:

Power Shovels	
Size of Shovel	Diesel
¾ cu. yd.	$ 42,000.00
1 cu. yd.	51,000.00
1¼ cu. yd.	63,000.00
1¾ cu. yd.	90,000.00
3¼ cu. yd.	136,000.00
4¼ cu. yd.	167,000.00
5½ cu. yd.	238,000.00

Dragline Excavators Including a Medium Duty Bucket

Size of Dragline	Diesel
½ cu. yd.	$ 38,000.0
¾ cu. yd.	46,000.0
1 cu. yd.	57,000.0
1¼ cu. yd.	78,000.0
2½ cu. yd.	117,000.0
3 cu. yd.	142,000.0
3½ cu. yd.	193,000.0

Clamshell Excavators Including a Medium Duty Bucket

Size of Clamshell	Diesel
½ cu. yd.	$ 38,000.0
¾ cu. yd.	46,000.0
1 cu. yd.	56,000.0
1¼ cu. yd.	77,000.0
2½ cu. yd.	116,000.0
3 cu. yd.	139,000.0
3½ cu. yd.	189,000.0

Lift Cranes

Capacity	Diesel
12 ton	$ 37,000.0
20 ton	45,000.0
22 ton	56,000.0
40 ton	77,000.0
44 ton	115,000.0
45 ton	139,000.0
75 ton	187,000.0

Basic Power Shovel Unit and Front End Attachments.—It generally known that power cranes and shovels are applied varying as well as extremely broad ranges of work and eve changing working conditions. So variable, in fact, that proper a plications of the basic units with attachments and working toc often times appear to conflict

Naturally, the ideal situation would be to have the most sui able power shovel, crane or dragline, as the case may be, for ea job that is undertaken. Although very sound in principle, this seldom economically practical or profitable. More frequently, t contractor must take into consideration the handling of a wi range of work entailing varying conditions, requiring more less frequent and easy conversion from, for example, shovel dragline or crane to clamshell, etc., by simply changing attac ments on the basic unit to meet the varying job requiremen Power cranes and shovels, therefore, are designed to accomm date a wide range of front-end attachments and working tools meet the various job requirements.

The attachments are classified into three basic groups: The shovel boom, the crane type boom and the hoe boom. These attachments generally are interchangeable in the field.

Since the basic purpose of the shovel boom is for shovel work and the hoe boom for hoe work, the crane type boom serves for all other materials handling tools some of which are as follows: dragline buckets, clamshell buckets, orange peel buckets, hooks, hook blocks, tongs, grabs, clamps, grapples, concrete buckets, skull crackers and pile driving leads.

Crane type booms can be extended for extremely high lifts by inserting standard sections in the center of the boom, and by boom tip extensions (jibs). These jibs are used primarily to extend horizontal reach with boom raised vertically close to maximum elevation. They also provide an increase in vertical lifting range. Since the jib adds weight at the outer lifting radius and extends the working range, it has a limiting effect on lifting capacity.

To the price f.o.b. factory must be added the cost of freight, unloading, erecting and moving to the job. An approximate rate of $2.15 per 100 lbs. is a good average for delivery in the United States.

The unloading and erecting cost will vary with the size of the machine. A rough estimate of the amount of labor and material is given below. Labor is assumed to be ⅓ skilled and ⅔ unskilled.

Mach. Cap. Cu. Yds.	Approx. Shipping Weight-Lbs.	Number Cars	No. Men Required	Man Hours	Material Cost
½	48,000	1	2-3	25	$100.00
¾	48,000	1	2-3	25	120.00
1	58,000	1	3-4	35	150.00
1¼	68,000	1	3-4	35	150.00
2½	112,000	1	3-4	35	200.00
3	174,000	2	4-6	100	350.00
3½	201,000	2	4-6	100	400.00

Using local labor rates, the above will give a fair estimate although the cost of unloading material will vary with market prices and locality.

Average Useful Life of Power Shovels, Hoes and Cranes.—A reasonable allowance for the exhaustion, wear and tear of property used in trade or business, including a reasonable allowance for obsolescence is permitted in figuring depreciation on your equipment.

The figures tabulated below are taken in part from Government Bulletin No. 456, "Depreciation Guide Lines and Rules,"

revised Aug. 1964, of the U. S. Treasury Dept. Internal Revenue Service.

Average Useful Life of Power Shovels and Hoes

⅜–¾ cu. yds.	5 years	or	10,000 hours
1–1½ cu. yds.	6 years	or	12,000 hours
2 cu. yds. and over	8 years	or	16,000 hours

Average Useful Life of Draglines, Clamshells and Cranes

Cu. Yds.	Tons	Years	Hour
⅜-¾	2½-5	5	10,00
1-1½	10-15	9	18,00
2 and over	20 and over	12	24,00

The grouping shown for lifting cranes is a separate groupin and does not necessarily relate to the machines by size in cu. yds For example, many ¾ cu. yd. excavators (clamshell or dragline would have a greater rating than 5 tons and might be rated i tons to fall in a different group than they do as excavators.

Depreciation.—The straight line method of figuring depreciation is used. This method is in general adequate for this purpose however if it is desired to take changing prices for equipment int account in estimating, an annual appraisal to determine a currer value should be considered.

Therefore, for the years and hours used, the following per centage of depreciation for the various groups are used:

Years	Hours	% per Year	% per Hour
5	10,000	20 %	.01 %
6	12,000	16.67%	.00833%
8	16,000	12.5 %	.00625%
9	18,000	11.11%	.00555%
12	24,000	8.33%	.00416%

Interest, Taxes and Insurance.—Interest, taxes, insuranc storage are usually charged at 10% of the average investmer of which 6% is interest and 4% covers taxes, insurance, storag and incidentals.

Average investment must be established, based on the numb of years used for depreciation. Since the first year is considere as 100% and since the investment is considered at the beginnir of each year, the method of calculating average investment f a 5 year depreciation period is as follows:

1st year	100% of Total Investment
2nd year	80% of Total Investment
3rd year	60% of Total Investment
4th year	40% of Total Investment
5th year	20% of Total Investment
	300% of Total Investment

Average investment equals 300% divided by 5 years equals 60% of Total Investment.

The percent of Total Investment to use for Average Investment for 5, 6, 8, 9 and 12 year periods are as follows:

No. Years Depreciation	Percent Average Investment per Year
5	60 %
6	58.33%
8	56.25%
9	55.56%
12	54.17%

Therefore, the percentage of Total Investment per year and per hour to use for interest, insurance, taxes and storage, based on 10 percent of average investment for the groups considered here is as follows:

Interest, Insurance, Taxes, Storage

Based on 10 percent of Average investment per year.

Percent Average Investment per Year	Years	Hours	Percent of Total Investment Per Year	Per Hour
60 %	5	10,000	6 %	.003 %
58.33%	6	12,000	5.83 %	.00292%
56.25%	8	16,000	5.625%	.00281%
55.56%	9	18,000	5.56 %	.00278%
54.17%	12	24,000	5.42 %	.00271%

Fixed Costs, Repairs, Maintenance and Supplies.—The percentage cost of repairs, maintenance and supplies is one of the most difficult to estimate. The figures used are not based on actual records but are believed to be a fair representative average. In the case of shovels and hoes, this cost is based on 100 percent of the total investment spread over the life of the machine, and includes repairs, replacement parts and repair labor for normal operation, and includes such items as ropes, dipper and bucket teeth, oil and grease for lubricating machinery, as well as seasonal overhaul. They do not include engine fuel or lubricating oil.

In the case of draglines and clamshells, 80% of the total investment spread over the economic life of the machine is a fair average cost of these items.

In the case of lifting cranes 60% of the total investment spread over the economic life of the machine may be used.

The owner of an excavator should anticipate three things in regard to repairs and maintenance. First, the average figures used presume proper maintenance. Without this repair bills will greatly exceed the estimates given here. Second, it is assumed the equipment will be used within its specified rating. Third, these expenses are not uniform each year. Provision

should be made for a periodic general overhaul, and it shoul be expected that both the amount of repairs required and th losses caused by shutdowns will increase as the equipmen becomes older.

Repairs, Maintenance and Supplies, Including Labor Associated With Them

Shovels and Hoes

Based on 100 percent of Total Investment Spread over Lif of Machine.

Cu. Yds.	Years	Hours	Percent of Total Investmen Per Year	Per Hour
$\frac{3}{8}$–$\frac{3}{4}$	5	10,000	20 %	.01 %
1–1$\frac{1}{2}$	6	12,000	16.67%	.00833%
2–3$\frac{1}{2}$	8	16,000	12.5 %	.00625%

For example: Assume a $\frac{3}{4}$-cu. yd. shovel cost $42,000.00. Repairs, maintenance and supplies equal $42,000.00 x .0001 = $4.20 per hr.

Draglines and Clamshells

Based on 80 percent of Total Investment Spread over Life Machine.

Cu. Yds.	Years	Hours	Percent of Total Investme Per Year	Per Hour
$\frac{3}{8}$-$\frac{3}{4}$	5	10,000	16 %	.008 %
1-1$\frac{1}{2}$	9	18,000	8.89%	.00445%
2-3$\frac{1}{2}$	12	24,000	6.66%	.00333%

Lifting Cranes

Based on 60 percent of Total Investment Spread over Life Machine.

Tons	Years	Hours	Percent of Total Investm Per Year	Per Hou
2$\frac{1}{2}$-5	5	10,000	12 %	.006 %
10-15	9	18,000	6.67%	.00333%
20 and over	12	24,000	5 %	.0025 %

Operating Costs, Engine Fuel and Lubricating Oil.—A formu for estimating the approximate amount of diesel fuel consun tion for equipment of this type is as follows:

$$\frac{\text{BHP x Factor x lbs. fuel per hp hr.}}{\text{Weight of fuel per gallon}} = \text{gal. per hr.}$$

Where
BHP=Brake hp. of engine—or rated hp.
Factor=Factor for this use 50 to 60%.
Diesel=0.5 lbs. per brake horsepower hour.
Diesel=7.3 lbs. per gallon (U.S.)

From this formula we obtain an approximate diesel fuel consumption of 0.034 to 0.041 gallons per horsepower hour (based on 50% to 60% factor respectively), and suggest using an average of about 0.040 gal. per horsepower hour.

Shovels normally will consume a greater amount of fuel than the other types of machines considered here. Therefore the larger consumption rate indicated should be used for estimating fuel for shovels and the smaller rate for draglines and clamshells. Machines used for lifting crane service only, usually operate intermittently and fuel consumption is difficult to estimate but generally not an important consideration.

Example: A 100 horsepower engine in shovel service is estimated to consume per hour:
100 x .041=4.1 gals. Diesel fuel per hr.

Lubricating oil is considered with fuel as it varies with the size and type of engine. It usually includes a complete change every 100 hours plus make-up oil between changes.

Labor Operating Costs.—The price paid labor as well as the number in the operating crew varies in different parts of the country and on different jobs, to such an extent that each contractor must estimate this cost for himself. This cost is one of the most readily estimated. Some costs relating to crew costs besides rates of pay are Federal Insurance Contribution Act, Workmen's Compensation Insurance, Unemployment Compensation, Overtime, Paid Holidays, Contractor's Contributions to Union Welfare and Pension Funds, etc.

Power Shovel Yardages.—To estimate yardage production on a job is a real problem. If all conditions were the same on all jobs, it would be a simple matter, but jobs are as different as night and day. There are many factors which must be considered, many of which can be learned only through experience.

The type of material, the depth of cut for maximum effect, no delays in operation, a 90° swing for the shovel, all affect the output, let alone the conditions existing on the job and the type of management available.

The following table gives an approximate idea of the difference in maximum output possible, subject to the conditions as listed above.

Hourly Shovel Output in Cubic Yards

Shovel Capacity / Class of Material	⅜	½	¾	1	1¼	1½	1¾	2	2½
Moist Loam or Light Sandy Clay..	85	115	165	205	250	285	320	355	405
Sand and Gravel....	80	110	155	200	230	270	300	330	390
Good Common Earth.....	70	95	135	175	210	240	270	300	350
Clay, Hard and Tough....	50	75	110	145	180	210	235	265	310
Rock, Well Blasted.	40	60	95	125	155	180	205	230	275
Common Earth, with Rocks and Roots...	30	50	80	105	130	155	180	200	245
Clay, Wet and Sticky....	25	40	70	95	120	145	165	185	230
Rock, Poorly Blasted.....	15	25	50	75	95	115	140	160	19

The quantities given in the above table are based on bank measure which means cubic yards removed from the bank rather than cubic yards in the hauling unit. There is a big difference between a yard of dirt in the bank and a yard of dirt in the truck. This is because of the swell of the material or its increase in volume due to voids when it is dug or loosened. For instance, good common excavation will swell around 30 percent. Another condition is that the machine is working in a depth of cut suitable for maximum digging efficiency. The optimum depth of cut for various sizes of shovels, may be defined as that depth which produces the greatest output and at which the dipper comes up with a full load without undue crowding.

The output figures are based on continuous operations, 60 minutes a working hour, without any delays for adjustment, lubrication, operator stopping to light a cigar, etc.

The figures are based on each dipper-full of material being swung through an arc of 90° before dumping. This is important; a swing of either a lesser number or greater number of degrees than 90° will either save time or consume more time and affect output capacity accordingly.

Tables are based on all materials being loaded into hauling units, with the further understanding that these hauling units are properly sized to shovel capacity and are provided in sufficient quantities to take away all the material the shovel can dig.

While these figures represent a very comprehensive job as

as realistic a picture as can be presented on this involved subject, a word of caution is in order. These figures are general only and should not be considered as guaranteed outputs, or used by anyone as a basis for figuring and bidding jobs.

How Degrees of Swing and Depth of Cut Affect Shovel Yardage Output.—The quantities in the above table were based on a height of cut representing the optimum depth of cut and a swing of 90° was specified.

Since variations in either of these conditions will have considerable effect on the yardage output, the following chart shows what happens when swing and depth of cut vary from the conditions on which the previous basic hourly yardages were established.

Table Giving Effect of Depth of Cut and Angle of Swing On Power Shovel Output

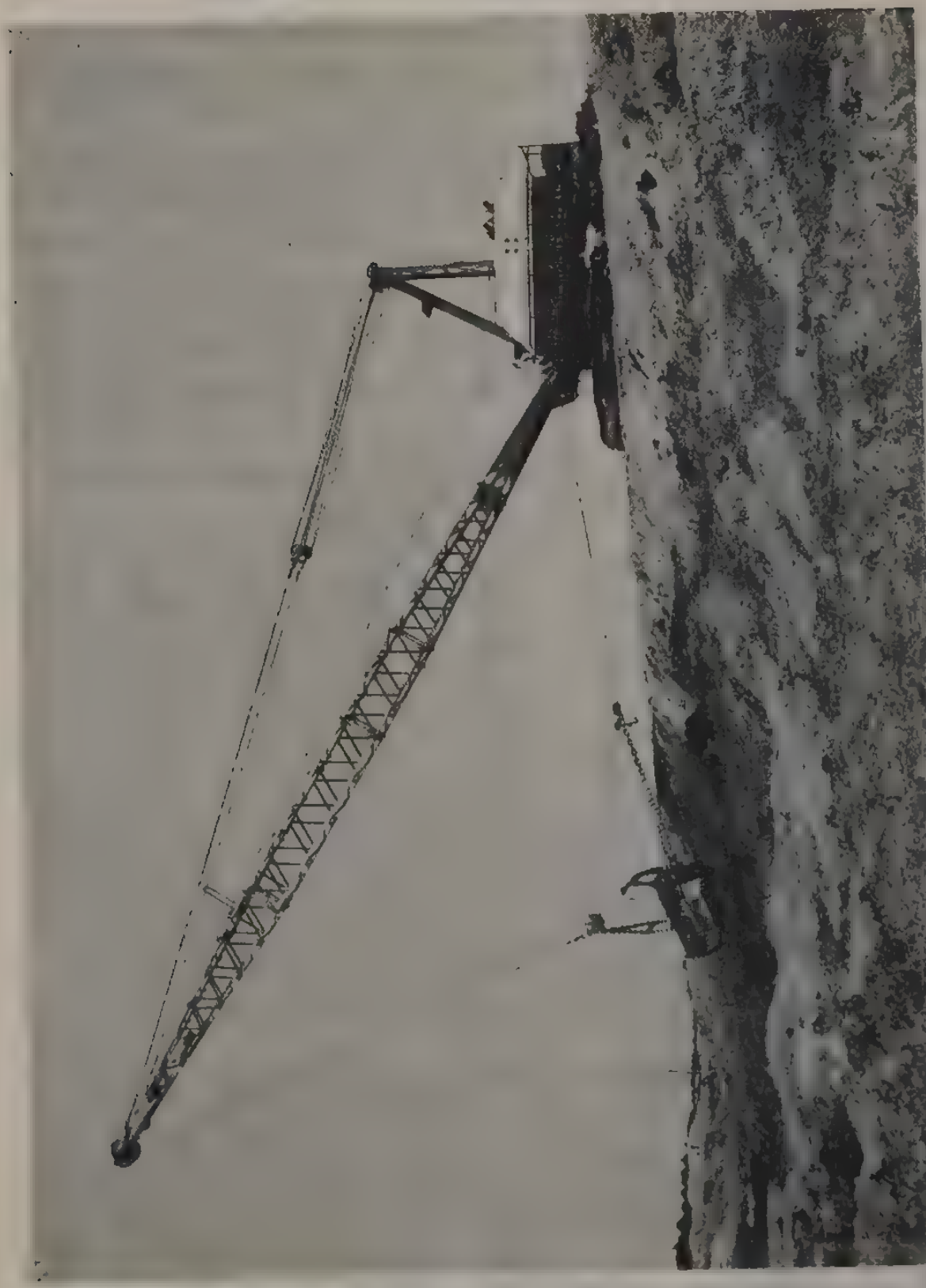
Depth of Cut in Percentage of Optimum	Angle of Swing in Degrees						
	45°	60°	75°	90°	120°	150°	180°
40	.93	.89	.85	.80	.72	.65	.59
60	1.10	1.03	.96	.91	.81	.73	.66
80	1.22	1.12	1.04	.98	.86	.77	.69
100	1.26	1.16	1.07	1.00	.88	.79	.71
120	1.20	1.11	1.03	.97	.86	.77	.70
140	1.12	1.04	.97	.91	.81	.73	.66
160	1.03	.96	.90	.85	.75	.67	.62

Dragline Yardages.—As in the case of power shovels and hoes, dragline yardage production is affected by the type of material to be excavated, the depth of cut, the swing before unloading, the type of unloading (unloaded into hauling units, cast onto spoil banks, etc.), the degree of continuity in the operation, etc.

The following table gives an approximate idea of the difference in maximum production possible subject to conditions listed thereafter:

Hourly Short Boom Dragline Output in Cubic Yards

Bucket Capacity Class of Material	⅜	½	¾	1	1¼	1½	1¾	2	2½
Moist Loam or	5.0′	5.5′	6.0′	6.6′	7.0′	7.4′	7.7′	8.0′	8.5′
Light Sandy Clay..	70	95	130	160	195	220	245	265	305
	5.0′	5.5′	6.0′	6.6′	7.0′	7.4′	7.7′	8.0′	8.5′
Sand and Gravel.....	65	90	125	155	185	210	235	255	295
Good	6.0′	6.7′	7.4′	8.0′	8.5′	9.0′	9.5′	9.9′	10.5′
Common Earth	55	75	105	135	165	190	210	230	265
Clay,	7.3′	8.0′	8.7′	9.3′	10.0′	10.7′	11.3′	11.8′	12.3′
Hard and Tough...	35	55	90	110	135	160	180	195	230
Clay,	7.3′	8.0′	8.7′	9.3′	10.0′	10.7′	11.3′	11.8′	12.3′
Wet and Sticky....	20	30	55	75	95	110	130	145	175



Dragline Excavator At Work

The production quantities in the above table are based on t
following conditions:

The quantities are in terms of bank measure.

The dragline is working in the optimum depth of cut for max
mum efficiency.

The dragline is working a full 60 minutes each hour—no delays
The dragline is making a 90° swing before unloading.
The bucket loads are being dumped into "properly sized" hauling units.
The proper type bucket is being used for the job.
The dragline is being used within the working radius recommended by the manufacturer for machine stability.

How Degrees of Swing and Depth of Cut Affect Dragline Yardage Output.—The following table gives the effect of depth of cut and angle of swing on dragline yardage production. Variations in degrees of swing, in particular, have a marked effect on production and this is important to keep in mind when laying out a job as the shorter the swing the more the yardage.

Table Giving Effect of Depth of Cut and Angle of Swing On Dragline Output

Depth of Cut in Percentage of Optimum	Angle of Swing in Degrees							
	30	45	60	75	90	120	150	180
20	1.06	.99	.94	.90	.87	.81	.75	.70
40	1.17	1.08	1.02	.97	.93	.85	.78	.72
60	1.24	1.13	1.06	1.01	.97	.88	.80	.74
80	1.29	1.17	1.09	1.04	.99	.90	.82	.76
100	1.32	1.19	1.11	1.05	1.00	.91	.83	.77
120	1.29	1.17	1.09	1.03	.985	.90	.82	.76
140	1.25	1.14	1.06	1.00	.96	.88	.81	.75
160	1.20	1.10	1.02	.97	.93	.85	.79	.73
180	1.15	1.05	.98	.94	.90	.82	.76	.71
200	1.10	1.00	.94	.90	.87	.79	.73	.69

Clamshell Production.—The clamshell excavator is not to be considered a high production machine but rather a machine to be used where the work is beyond the scope of other types of equipment. For example, a condition which usually requires a clamshell is where digging is vertical or practically straight down as in digging pier holes, shafts, etc. Digging in trenches which are sheathed and cross-braced generally calls for a clamshell because the vertical action of the bucket enables it to be worked through the cross-bracing. Jobs requiring accurate dumping or disposal of materials are usually clamshell jobs. Also, for high dumping jobs, whether it be charging a bin, building a stockpile or wherever the material must be dumped well above the machine level, the machine is well adapted. In general, the clamshell can operate vertically and dig or spot dump below, at or above the level of the machine.

The clamshell is only effective where the materials to be handled are relatively soft or loose.

Conditions are so variable on clamshell operation that a table showing typical production has little value.

However, in an effort to establish some point to work from, the following table has been prepared showing maximum production to be expected from clamshell excavators operating under the following conditions:

The clamshell is engaged in open digging such as a basement large footing, etc., with the permissible cut at least a full bucket depth.

The depth of the excavation is not over 10'-0".

The quantities are in terms of bank measure.

There is no wasted time, 60 minutes of digging each hour.

The clamshell is making a 90° swing before unloading.

The bucket loads are being dumped into "properly sized" hauling units.

The clamshell is being used within the working radius recommended by the manufacturer for machine stability.

Hourly Short Boom Clamshell Handling Capacity in Cubic Yard

Class of Material	⅜	½	¾	1	1¼	1½	1¾	2	2½
Moist Loam or Sandy Clay	50	65	95	120	140	155	170	190	22
Sand and Gravel	45	60	85	110	130	140	160	175	20
Good Common Earth	40	55	70	95	115	125	145	160	18

It must be thoroughly understood that the above production is based on the most ideal conditions with 100% job and management factors.

How Degrees of Swing Affect Clamshell Yardage.—The output of a clamshell operating at a steady pace is affected by the swing before unloading in the same manner as a dragline. The following table gives the effect of angle of swing on clamshell yardage production.

Angle of Swing in Degrees							
30°	45°	60°	75°	90°	120°	150°	180°
1.32	1.19	1.11	1.05	1.00	.91	.83	.77

Job and Management Factors.—Perfect conditions seldom exist on any construction job, therefore it is necessary to rationalize these figures by some other factor to compensate for the fact that actual job conditions differ widely from the perfect conditions assumed so far.

There are two sets of factors on every job which have a great deal to do with the output of equipment on the job. They are the job factor and the management factor.

Job factors are the physical conditions pertaining to a specific job which affect the production rate, other than the class of material to be handled. These may be divided into three general headings.

1. Topography and the dimensions of the work, which include the depth of cut and whether the work will require much moving within the cut or from one cut to another.

2. Surface and weather conditions, which include in some cases the difference between summer and winter work, and also the question of drainage of either surface or underground water.

3. Specification requirements which control the manner in which the work must be handled; or indicate the sequence of various operations; and which also show the amount of bank sloping or cutting close to finished line and grade that is required.

The above conditions are all inherent in the job itself and can be taken into account by the contractor in making up the bid.

Another group of factors which affect output are the management factors. These cover conditions which pertain to the efficiency of the operation and thus affect output. These are grouped under the head of the management factor because, in general, they are made up of items which management can determine and control. These include—

1. Selection, training and direction of men. The quantities given in the tables indicate what can be reasonably expected by an experienced operator who is willing to work. The availability of trained men and the incentive to produce must be considered.

2. Selection, care and repair of equipment. The quality of the inspection and preventive maintenance program can have much to do with the lost time on the job.

3. Planning, laying out the job, supervising and coordinating the operations is a very important factor in increasing efficiency. Providing the right number and size of hauling units is one of the first things to show its effect.

Foremanship and supervision are important. When everything is working smoothly, there is added incentive for high production rates.

Because both job and management factors must be considered jointly, that is, the output yardages must be modified by both a job and a management factor, the following table consolidates both.

To estimate the yardage, select the proper combined job and

management factor from the following table. First, select a job factor classification of Excellent, Good, Fair or Poor, whichever applies to your job conditions and follow straight across the Management Factor Classification of Excellent, Good, Fair or Poor, whichever applies to the management conditions. The resulting figure is the combination job-management factor by which the yardage figures from the basic output tables (as modified by the conversion factors for depth of cut and swing) must be multiplied to give the yardage factor that can reasonably be expected under the job-management conditions that will exist on the job.

Usually pit and quarry and heavy construction jobs will fall into groups 1, 2 or 3, whereas highway grading will usually fall into groups 2, 3 or 4 because of the variations in cuts, required machine travel, close cuts, etc.

Combination Job and Management Factors

	MANAGEMENT FACTORS			
JOB FACTORS	1 Excellent	2 Good	3 Fair	4 Poor
1. Excellent	.84	.81	.76	.70
2. Good	.78	.75	.71	.65
3. Fair	.72	.69	.65	.60
4. Poor	.63	.61	.57	.52

Power Shovel Excavating

The cost of power shovel excavating will vary with the size of the job, size of the shovel, and the speed with which the trucks are handled in and out of the hole, as it is seldom the shovel can work to capacity on building work, due to the congestion of trucks waiting to get in or out of the hole or due to trucks being delayed at the dump.

Modern shovels, powered by gasoline or diesel motors, have tremendous capacity when conditions permit working without interruptions, and while this may often be possible on heavy construction operations, it is seldom possible on building excavations, due to cramped quarters, traffic delays in cities, congestion of trucks waiting to get in or out of the hole, delays at dump, bad weather, etc., so it is never safe to figure maximum output for either shovel or trucks.

The size of the job has considerable bearing on the costs, as it costs just as much to get the shovel to the job and remove it at completion for 1,000 cu. yds. as for a 10,000 cu. yd. job.

Where it is possible to use a ¾-cu. yd. shovel to capacity (figuring a 100% dipper load each cycle), it should excavate

135 cu. yds. an hr. but the dipper is not always filled to capacity and there are delays in loading, moving shovel from place to place, cleaning up, bad weather, etc., so the average on building work will probably run 50 to 60 per cent of the rated capacity of the shovel.

Basis for Computing Daily Output of Diesel Powered Shovel.—The following method is used in figuring the output of a power shovel in basement excavation, based on a 1 cu. yd. shovel:

Dipper capacity .....1 Cu. Yd.
Dipper efficiency, average material .....90 percent
Load carried .....0.9 Cu. Yds.
Average operating cycle .....20 Seconds
Cycles per hour .....180 Cycles
Cu. Yds. per hour, operating 100% time.....162 Cu. Yds.
Operating efficiency in basement excavation due to haulage service, machine delays and cleanup work, approximately .....50 to 60 percent
Average output per 8-hr. day .....640 to 760 Cu. Yds.
Operating efficiency on heavy construction, roads, dams, open cut excavation, etc., including machine delays and cleanup work, approximately 66⅔ percent.
Average output per 8-hr. day .....864 Cu. Yds.

Dragline Excavating

The cost of dragline excavating will vary, in the same manner as shovel excavating, according to the size of the job, size of the machine and the capacity and speed of the hauling units although the hauling hazards are reduced substantially by the trucks not having to be loaded in the hole thereby eliminating the necessity of trucking up a ramp.

As may be determined by comparing the basic output tables for shovels and draglines, the dragline has about 75 to 80 percent of the basic output capacity of shovels in materials it can handle. However, the dragline definitely has a place in excavating for construction work by virtue of its generous digging reach, its ability to dig under extremely wet conditions since it may stand on the top on dry, firm footing, easier to haul from with no ramps to climb, etc., all conditions which, under certain circumstances, would make shovel digging very expensive if not totally impossible.

Clamshell Excavator

Clamshell Excavator Loading Concrete Aggregates.

In excavating for building construction the dragline is affected by job and management factors the same as shovels and the same basis for computing daily output may be used as follows:

Basis for Computing Daily Output of Dragline Excavator.—The following is based on a dragline having a 1 cu. yd. bucket.

Bucket capacity.....1 Cu. Yd.
Bucket efficiency, average material.....90 percent
Load carried .....0.9 Cu. Yds.
Average operating cycle..... .24 Seconds
Cycles per hour.....150 Cycles
Cu. Yds. per hour, operating 100% time.....135 Cu. Yds.
Operating efficiency in basement excavation due to machine delays, traffic delays to hauling units and clean up work, approximately..... .....50 to 60 percent
Average output per 8-hr. day.....540 to 650 Cu. Yds.
Operating efficiency on heavy construction, roads, dams, open cut excavation, etc., including machine delays and clean up work, approximately.....66⅔ percent
Average output per 8-hr. day.....720 Cu. Yds.

Clamshell Excavating

Clamshell excavators are usually used on a job when no other machine method will work and working conditions generally preclude the possibility of any good yardage production. However, some idea of daily production may be gained from the following data based on using a 1 cu. yd. clamshell, digging in average soil and loading properly sized hauling units.

Type of Excavation	Daily Production
Open digging, basements, etc.	350 to 400 cu. yds.
Trench digging, 4'-0" to 10'-0" wide, 3'-0" to 10'-0" deep, no obstructions	300 to 350 cu. yds.
Individual column footings	200 to 250 cu. yds.

Power Hoe Excavating

The hoe may be said to be a cross between a dragline and a shovel as it incorporates some of the characteristics of each and overcomes some of the limitations of each. The hoe, of course, is primarily a unit to dig below machine level. It will, however, dig harder material than the clamshell or dragline because the weight of the boom itself may be used to force or crowd the dipper into the material. It is, however, limited in digging by the length of the boom and stick. The hoe dipper may be controlled more accurately than the dragline bucket and is therefore better suited to close limit work.

In building construction the hoe is used to dig trenches, footings and basements. On small residence basements the hoe offers many advantages. It digs straight, vertical side walls (in soil which will stand); it cuts a level floor; it trims corners neatly and squarely; it can dig sewer and waterline trenches; it always works from the top on dry, safe ground; it reduces hand trim to a minimum.

In general, the process of digging a basement with a hoe is to dig a trench around the four sides of the basement and scoop out the center as you go. The set-ups for different jobs may vary because of nearby houses, available space for disposal of materials, etc.

On small work it is necessary to have a low-cost, simple and easy means of moving the shovel from job to job. This is best done by using a single-purpose trailer which can be loaded or unloaded in 15 to 20 minutes. The load is carried on 12 balloon type, heavy duty industrial tires. The cost of moving the hoe from job to job will vary with the length of the haul or the distance between jobs.

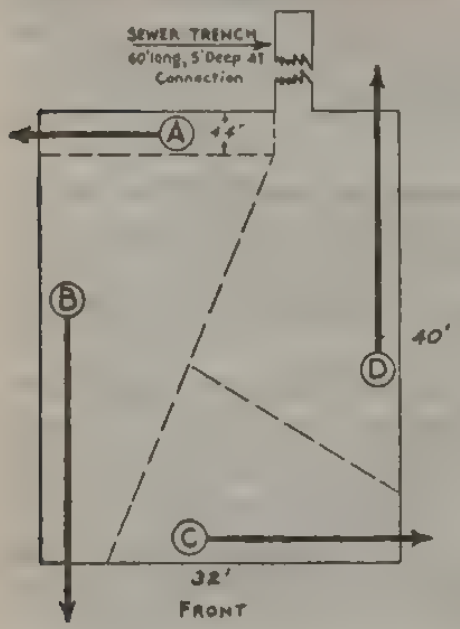
On time studies made on several small basement jobs, where the basements contained from 275 to 350 cu. yds. of excavation each, a hoe power excavator equipped with a ¾-cu. yd. dipper averaged from 66 to 88 cu. yds. per hour.

An example of the cost of excavating a small basement containing approximately 350 cu. yds. of excavation, with the soil placed around the excavation, is as follows:

	Hours	Rate	Total	Rate	Total
Truck and trailer	4	$.....	$.....	$10.50	$ 42.00
Hoe operator	4	.....	.....	6.75	27.00
Labor	4	.....	.....	5.00	20.00
Excavating					
Hoe operator	4	.....	.....	6.75	27.00
Labor, clean-up	4	.....	.....	5.00	20.00
Hoe charge	8	.....	.....	8.60	68.80
Total Direct Cost	28		$.....		$204.80
Compensation and Liability Insurance			.....		6.20
Old Age Ben. and Unemp. Comp.			.....		5.00
Overhead exp. & profit			.....		108.00
Total Cost			$.....		$324.00
Cost per cu. yd.			.....		.93

Supervision, overhead expense and profit will vary from 25% to 50%, depending upon size of job, desirability of work, etc.

Above costs do not include removal of excavated earth from site or backfilling.



Digging plan for excavating small basements using a hoe type power shovel. The order of the letters indicates the order in which the sections are removed. The arrows indicate the direction the hoe travels in taking out each section.

Truck and trailer time bringing up shovel and removing same at completion of job will vary with length of haul.

In medium to large work and at moderate depths hoe production can approach that of shovels. Output falls off considerably, however, at greater depths.

For the smaller machines, the size hoe is usually chosen for the width trench it will cut but for the larger sizes the capacity is usually the same the basic machine unit could handle as a shovel and is chosen on a production basis.

Data on typical hoe bucket dimensions and weight is given in the following table.

Dipper Capacity in Cu. Yds. Struck	Bucket Outside Width in Inches	Total Width Added for Two Side Cutters in Inches	Weight in Lbs.
⅜	20 to 24	4 or 6	850
½	24 to 28	4 to 9	950
¾	28 to 39	4 to 9	1,400
1	33 to 45	4 to 9	1,700
1¼	39 to 45	4 to 9	2,000
1½	39 to 45	4 to 9	2,300
2	47 to 55	4 to 7	3,200

Specimen Excavating Estimate

Based on basement containing 5,000 cu. yds. excavation, average conditions, using a ¾ cu. yd. power shovel, loading into trucks, based on an average of 600 cu. yds. per 8-hr. day.

Bringing Shovel to Job	Hours	Rate	Total	Rate	Total
Truck and Trailer	8	$.....	$.....	$10.50	$ 84.00
Foreman	8	.....	.....	7.00	56.00
Shovel operator	8	.....	.....	6.75	54.00
Labor	16	.....	.....	5.00	80.00
Excavating					
Foreman	68	.....	.....	7.00	476.00
Shovel operator	68	.....	.....	6.75	459.00
Labor	136	.....	.....	5.00	680.00
Removing Shovel at Completion					
Truck and Trailer	8	.....	.....	10.50	84.00
Foreman	8	.....	.....	7.00	56.00
Shovel operator	8	.....	.....	6.75	54.00
Labor	16	.....	.....	5.00	80.00
Shovel charge	84	.....	.....	8.60	712.40
Building and removing inclined runway			.....	.....	950.00
Total Direct Cost	516		$.....		$3825.40
Compensation and Liability Insurance.			.....		191.00
Old Age Ben. and Unemp. Comp.			.....		152.00
Overhead expense and profit			.....		2084.00
Total Cost			$.....		$6252.40
Cost per cu. yd.			.....		$1.25

Add for trucks removing excavated soil.

Supervision, overhead expense and profit may vary from 25% to 50%, depending upon size of job, degree of risk, desirability of work, etc.

The above method for estimating shovel excavation can also be used for hoe, dragline and clamshell excavation by merely substituting the proper production values and equipment charges for those pertaining to shovels.

Hauling Excavated Materials in Motor Trucks

Where an excess of excavated materials, over and above the amount required for backfill exists, it will have to be removed from the job and in most cases by motor trucks.

The usual procedure followed in these cases is to determine beforehand the approximate quantity of material required for backfill, etc., and this amount subtracted from the estimated excavation quantity will give the volume of excavated material to be hauled away. The excess material should be loaded and hauled as the excavation progresses so that no rehandling is necessary.

Types of Motor Trucks.—Motor truck hauling units are mainly of two types, namely: conventional highway hauling units and off-the-highway heavy duty hauling equipment.

The conventional highway hauling unit is familiar to every

Data on Diesel Power Shovel Costs and Operation

Description	Size of Shovel						
	¾ Cu. Yd.	1 Cu. Yd.	1¼ Cu. Yd.	1¾ Cu. Yd.	3¼ Cu. Yd.	4¼ Cu. Yd.	5½ Cu. Yd.
Cu. Yds. per Hour Based on 100% Time, Cu. Yds.	135	180	225	315	585	765	950
Cu. Yds. per Hour Based on 100% Time and 90% Dipper Efficiency	121	162	202	284	525	690	855
Output per Hour Based on 66⅔% Efficiency, Cu Yds	90	120	150	210	390	510	635
Output per Hour Based on 50% Efficiency, Cu. Yds	68	90	112	157	292	382	475
Output per 8-Hour Day, Based on 66⅔% Efficiency, Cu. Yds.	720	960	1200	1680	3120	4080	5075
Output per 8-Hour Day, Based on 50% Efficiency, Cu. Yds.	544	720	1000	1260	2340	3060	3800
Average Cost—Diesel Shovel, Including Freight and Unloading	$43,000	$54,000	$67,000	95,000	$142,000	$174,000	$245,000
Depreciation, Percent per Year	20%	16⅔%	16⅔%	16⅔%	12½%	10%	10%
Depreciation per Hour Based on 2,000 Hours per Year	$4.30	$4.50	$5.58	$7.92	$8.88	$8.70	$12.25
Interest, Taxes, Insurance, 10% per Year of 2,000 Hours	$1.29	$1.58	$1.96	$2.78	$3.99	$4.80	$6.75
Hourly Consumption of Fuel, Approximate Gals per Hour	4.5	4.5	5.2	6.4	12.0	15.5	18.0
Fuel Cost per Hour*	$0.90	$0.90	$1.04	$1.28	$2.40	$3.10	$3.60
Engine Lub Oil Cost, per Hour	$0.08	$0.10	$0.12	$0.20	$0.24	$0.32	$0.40
Cost per Hour, Repairs, Maintenance and Supplies, Including Rope, Grease, etc.	$4.30	$4.50	$5.58	$7.92	$8.88	$8.70	$12.25
Total Hourly Cost, Not Including Labor, Supervision, Compensation, Unemployment, Soc Sec, etc	$10 87	$11.58	$14.28	$20.10	$24.39	$25.62	$35.25

*Fuel costs based on Diesel fuel at 20 cts. per gal.

Typical Example of Excavating Using a Modern Power Shovel

Cost of Power Shovel Excavating Using a ⅜-Cu. Yd. Shovel Based on an Average Daily Output of 300 Cu. Yds.

	Number of Cubic Yards of Excavation in Job						
	1,000	1,500	2,000	2,500	3,000	4,000	5,00
Bringing Shovel to Job and Setting Up							
Foreman*	8	8	8	8	8	8	8
Shovel Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Actual Operating Time of Shovel							
Foreman*	27	40	54	67	80	107	134
Shovel Operator	27	40	54	67	80	107	134
Labor	54	80	108	134	160	214	268
Removing Shovel at Completion							
Foreman*	8	8	8	8	8	8	8
Shovel Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Shovel Charge at $ per Hr.	43	56	70	83	96	123	150
Cost Bringing Shovel to Job and Removing Same at Completion, Truck Hours	16	16	16	16	16	16	16
Insurance, Compensation, Public Liability, Old Age and Unemployment Taxes							
Overhead Expense and Profit							

Cost of Power Shovel Excavating Using a ½-Cu. Yd. Shovel Based on an Average Daily Output of 400 Cu. Yds.

	Number of Cubic Yards of Excavation in Job						
	1,000	1,500	2,000	2,500	3,000	4,000	5,000
Bringing Shovel to Job and Setting Up							
Foreman*	8	8	8	8	8	8	8
Shovel Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Actual Operating Time of Shovel							
Foreman*	20	30	40	50	60	80	100
Shovel Operator	20	30	40	50	60	80	100
Labor	40	60	80	100	120	160	200
Removing Shovel at Completion							
Foreman*	8	8	8	8	8	8	8
Shovel Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Shovel Charge at $ per Hr.	36	46	56	66	76	96	116
Cost Bringin gShovel to Job and Removing Same at Completion, Truck Hours	16	16	16	16	16	16	16
Insurance, Compensation, Public Liability, Old Age and Unemployment Taxes							
Overhead Expense and Profit							

*Foreman in Charge of Job, handling and expediting trucks, etc.

Cost of Power Shovel Excavating Using a ¾-Cu. Yd. Shovel Based on an Average Daily Output of 600 Cu. Yds.

	Number of Cubic Yards of Excavation in Job						
	1,000	1,500	2,000	2,500	3,000	4,000	5,000
Bringing Shovel to Job and Setting Up							
Foreman*	8	8	8	8	8	8	8
Shovel Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Actual Operating Time of Shovel							
Foreman*	14	20	27	34	40	54	68
Shovel Operator	14	20	27	34	40	54	68
Labor	28	40	54	68	80	108	136
Removing Shovel at Completion							
Foreman*	8	8	8	8	8	8	8
Shovel Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Shovel Charge at $ per Hr	30	36	43	50	56	70	84
Cost Bringing Shovel to Job and Removing Same at Completion, Truck Hours	16	16	16	16	16	16	16
Insurance, Compensation, Public Liability, Old Age and Unemployment Taxes							
Overhead Expense and Profit							

Cost of Power Shovel Excavating Using a 1-Cu. Yd. Shovel Based on an Average Daily Output of 720 Cu. Yds.

	Number of Cubic Yards of Excavation in Job						
	1,000	1,500	2,000	2,500	3,000	4,000	5,000
Bringing Shovel to Job and Setting Up							
Foreman*	8	8	8	8	8	8	8
Shovel Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Actual Operating Time of Shovel							
Foreman*	11	17	22	28	34	45	56
Shovel Operator	11	17	22	28	34	45	56
Labor	22	34	44	56	68	90	112
Removing Shovel at Completion							
Foreman*	8	8	8	8	8	8	8
Shovel Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Shovel Charge at $ per Hr	27	33	38	44	50	61	72
Cost Bringing Shovel to Job and Removing Same at Completion, Truck Hours	16	16	16	16	16	16	16
Insurance, Compensation, Public Liability, Old Age and Unemployment Taxes							
Overhead Expense and Profit							

*Foreman in Charge of Job, handling and expediting trucks, etc.

Cost of Dragline Excavating Using a ½-Cu. Yd. Dragline Based on an Average Daily Output of 320 Cu. Yds.

	Number of Cubic Yards of Excavation in Job						
	1,000	1,500	2,000	2,500	3,000	4,000	5,000
Bringing Dragline to Job and Setting Up							
Foreman*	8	8	8	8	8	8	8
Dragline Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Actual Operating Time							
Foreman*	25	38	50	63	75	100	125
Dragline Operator	25	38	50	63	75	100	125
Labor	50	76	100	126	150	200	250
Removing Dragline at Completion							
Foreman*	8	8	8	8	8	8	8
Dragline Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Dragline Charge at $ per Hr.	41	54	66	79	91	116	141
Cost Bringing Dragline to Job and Removing Same at Completion, Truck Hours	16	16	16	16	16	16	16
Insurance, Compensation, Public Liability, Old Age and Unemployment Taxes							
Overhead Expense and Profit							

Cost of Dragline Excavating Using a 1-Cu. Yd. Dragline Based on an Average Daily Output of 560 Cu. Yds.

	Number of Cubic Yards of Excavation in Job						
	1,000	1,500	2,000	2,500	3,000	4,000	5,000
Bringing Dragline to Job and Setting Up							
Foreman*	8	8	8	8	8	8	8
Dragline Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Actual Operating Time							
Foreman*	18	27	36	45	54	72	90
Dragline Operator	18	27	36	45	54	72	90
Labor	36	54	72	90	108	144	180
Removing Dragline at Completion							
Foreman*	8	8	8	8	8	8	8
Dragline Operator	8	8	8	8	8	8	8
Labor	16	16	16	16	16	16	16
Dragline Charge at $ per Hr.	34	43	52	61	70	88	190
Cost Bringing Dragline to Job and Removing Same at Completion, Truck Hours	16	16	16	16	16	16	16
Insurance, Compensation, Public Liability, Old Age and Unemployment Taxes							
Overhead Expense and Profit							

*Foreman in Charge of Job, handling and expediting trucks, etc.

Hoe Type Power Shovel Excavating for Sewer

contractor and is the most frequently used. For the average con tractor it is the most economical type of truck to use as it i adaptable to practically every job and may be used for othe hauling purposes as well.

For the contractor specializing in large earth moving project the high production, heavy duty, off-the-highway hauling unit i the most economical equipment to use because it is specifically designed for this purpose and not being limited by state highwa regulations, as to weight and size, has a high ratio of net weigh to payload, the additional weight being found in its more rugge construction, such as heavier frame, axles, body, hoist, engine, etc

Hourly Cost of Ownership and Operation of Motor Trucks.— To intelligently estimate hauling costs the contractor must kno what the equipment costs to own and operate and this may b determined by the same method previously described for exca vating equipment.

Attention is called to the manner in which tire costs, original replacement and repair are handled. Recognizing the fact tha the economic life of tires will not be as long as the life of th vehicle, the original value of the tires is deducted from the tota price before computing the hourly charge for depreciation an is then treated as an operating cost.

The hourly cost of tire replacement and tire repairs varie greatly according to operating conditions, road surfaces and tir loadings. While tire costs in ordinary trucking operations nor mally are figured on a mileage basis, in construction work, wit its rough roads, short hauls and relatively low speeds (below 3 mph.), they are figured on an hourly basis and are computed b dividing the replacement cost by the estimated tire life in hours The average life expectancy of truck tires in construction wor is from 3,000 to 3,500 hours. Tire repairs should run about 1 percent of the hourly tire cost.

The following tables give data on various sizes of rear dum trucks for both conventional highway hauling units and heav duty off-highway equipment.

Table Showing How Hourly Cost of Ownership and Operatio May Be Derived for Conventional Highway Rear Dump Trucks Used in Construction Work Based on an Economic Life of 3 Yrs. of 2,000 Hours Each

Capacity in Tons	5	6	7	8	10
Capacity in Cu. Yds., Water Level	3	4	4.5	5	7
Horsepower	110	135	150	160	160
Approximate Delivered Price	$3,700	$5,100	$6,600	$7,600	$10,30
Original Tire Value	600	750	900	1,000	1,25

Depreciation, .0167% of Total Investment Less Tires	$ 0.52	$ 0.73	$ 0.95	$ 1.10	$ 1.51
Interest, Taxes and Insurance, .0033% of Total Investment	0.09	0.17	0.22	0.25	0.34
Hourly Tire Replacement Cost, Based on 3,000-Hr. Life	0.20	0.25	0.30	0.33	0.42
Hourly Cost of Tire Repairs, 15% of Hourly Tire Replacement Cost	0.03	0.04	0.05	0.05	0.06
Maintenance and Repairs, .004% of Total Investment	0.15	0.20	0.26	0.30	0.41
Fuel Cost per Hour, .04 Gal. per Hp.	1.32	1.62	1.80	1.92	1.92
Oil and Grease, 15% of Fuel	0.20	0.24	0.27	0.29	0.29
Total Hourly Cost, Not Including Labor, Supervision, Unemployment, Soc. Sec., Overhead Expense and Profit	2.51	3.25	3.85	4.24	4.95

Table Showing How Hourly Cost of Ownership and Operation May be Derived for Off-Highway Rear Dump Trucks Based on an Economic Life of 3 Yrs. of 2,000 Hours Each

Capacity in Tons	10	18	27	45	62
Capacity in Cu. Yds., Water Level	6.5	10.5	18	40	40
Horsepower	130	225	335	500	670
Approximate Delivered Price	$22,000	$30,000	$49,000	$70,000	$110,000
Original Tire Value	1,600	4,000	5,800	10,000	15,000
Depreciation, .01% of Total Investment Less Tires	2.04	2.60	4.32	6.00	9.50
Interest, Taxes and Insurance, .003% of Total Investment	0.66	0.90	1.47	2.10	3.30
Hourly Tire Replacement Cost, Based on 3,000-Hr. Life	0.53	1.34	1.94	3.33	5.00

Hourly Cost of Tire Repairs, 15% of Hourly Tire Replacement cost ....$	0.08	$ 0.20	$ 0.29	$ 0.50	$ 0.75
Maintenance and Repairs, .004% of Total Investment ..	0.88	1.20	1.96	2.80	4.40
Fuel Cost per Hour, .025 Gal. per Hp. ..	0.52	0.90	1.34	2.00	2.68
Oil and Grease, 15% of Fuel	0.08	0.14	0.20	0.30	0.40
Total Hourly Cost*..$	4.79	$ 7.28	$ 11.52	$ 17.03	$ 26.03

* The foregoing tables are for the purpose of showing the items which must be taken into consideration in figuring hourly costs but do not necessarily reflect current prices of equipment, tires or fuel.

Cost of Hauling Excavated Material in Trucks.—Hauling costs vary with the capacities of the trucks and time of the hauling cycle.

Truck capacity, for proper sizing, should be at least 4 times the dipper or bucket capacity of the excavator and should also be a multiple of that capacity. This is important as the efficiency of the excavator is seriously affected by undersized hauling units due to the increased hazards of truck delays.

The following table gives theoretical spotting time cycles for various sizes of power shovel excavators working at 100 percent efficiency and loading trucks of 4 times dipper size capacity.

Haul Units Needed to Spot Under Shovel per Hour in Medium Digging

Size Excavator Dipper	Minimum Haul Unit Capacity at 4 Times Dipper Size	Approximate Shovel Cycle in Seconds 90° Swing No Delays	Loading Time for 4-Dipper Truck in Seconds	Time of Spotting Cycle for Steady Operation in Minutes	Number of Spots Required per Hour for Steady Operation
⅜	1½ Yd.	19	76	1.26	48
½	2 Yd.	19	76	1.26	48
¾	3 Yd.	20	80	1.33	45
1	4 Yd.	21	84	1.40	43
1¼	5 Yd.	21	84	1.40	43
1½	6 Yd.	23	92	1.53	39
2	8 Yd.	25	100	1.66	36
2½	10 Yd.	26	104	1.73	35

For dragline operation the above time values may be increased from 20 to 30 percent.

The hauling time cycle consists of several operations, namely; spotting of truck under excavator; loading truck by excavator; traveling to dumping area; dumping; returning to excavator.

Some of these operations, such as spotting, loading and dumping, can be minimized by good management and supervision. Traveling time, however, will vary with the haul distance, traffic conditions, road conditions, etc., and must be carefully analyzed for each job.

When the hauling time cycle has been estimated, the number of loads each truck is able to haul per day can be determined and multiplying this by the capacity of the truck will give the theoretical daily haul of each truck in cu. yds., assuming 100 percent job efficiency. This amount should be multiplied by the expected job efficiency factor to obtain the net yardage hauled. Divide the daily truck cost by the net yardage hauled and the result will be the hauling cost per cu. yd.

The number of trucks required to keep the excavator going can also be determined by dividing the hauling time cycle by the loading time cycle using 100 percent excavator efficiency as a basis. This is done to be sure that a hauling unit is under the excavator at all times. While an excavating job may actually work out to a 50 or 60 percent efficiency, there usually are times on the job when the excavator is working at full capacity and to take advantage of this, sufficient, properly sized hauling units must be on the job. In large operations many contractors maintain standby units to step in when one of the hauling fleet trucks breaks down or is otherwise unusually delayed.

In sizing trucks to conform to dipper or bucket capacities, the struck capacity of each is used, assuming that the heaping of loads on both trucks and dippers or buckets will offset each other and produce bank measure quantities.

However, all estimating should use actual job data rather than theoretical figures. Some materials do not follow the usual swell ratios and job efficiency ratings vary widely. Following book figures to the letter in excavating, or any other branch of construction work, can be disastrous. Book values, at best, can only give what can be done under a definite set of conditions. The contractor must exercise his judgment in estimating this work and base his figure on his own particular set of conditions, i.e., his equipment, his supervision, his operators, his local materials and his local weather.

Tractors and Scrapers

The tractor is probably the most used piece of earth moving equipment on the construction job. It can perform a wide variety

of operations and equipped with the proper accessories is a high production and efficient tool for such jobs as site clearing, grading, shallow excavating, etc. In addition the tractor is often called upon to act as the "strong man" in freeing stuck trucks, hauling or dragging equipment, sheds, etc., into place, miscellaneous hoisting using a snatch block and cable, etc. In general, the tractor is almost indispensable on the job.

Equipped with bulldozer apparatus, the tractor, either rubber-tired or crawler type, has demonstrated its ability to do a wider variety of jobs than any other earth moving tool.

The bulldozer usually is employed to open up the job, which may consist of anything from clearing brush and vegetation to the removal of average size trees (up to 30 inches in diameter), stumps, rocks, paving, old floor slabs, old foundations, etc.

Stripping and stockpiling top soil on small quantity jobs with a haul distance from 200 to 400 feet or less is most efficiently done by bulldozer. On larger jobs this is done more economically by scrapers.

On small quantity, shallow excavation jobs with a short haul, tractor dozers are moderately efficient.

Crawler type bulldozers are reasonably economical on pushing distances up to 200 feet. Under the same conditions the rubber-tired dozer's economical push distance is about 400 feet.

Most backfilling jobs fall to the lot of the bulldozer where they out-perform any other piece of equipment.

Tractors also perform a valuable service when they are called upon to provide the additional power for push loading scrapers. On a production scraper job dozers helping to load these units more than pay for themselves.

On residence and other small jobs, a tractor shovel usually can dig the basement and do all exterior grading cuts and fills with maximum efficiency.

Another application of the bulldozer is spreading fill hauled in and dumped by trucks or cast by other excavating equipment.

Tractors are also the ideal power source for hauling sheepsfoot rollers and pneumatic rollers used in compacting fills.

Scraper Application.—Scrapers are high production earth moving units which are capable of digging their own load, hauling the load and then spreading the load in controlled layers. Furthermore, the scraper is a precision tool, as a skilled operator can cut a grade to within 0.1 ft. and can spread fill to the same degree of accuracy.

Scrapers may be powered by three types of prime movers: two wheeled or four wheeled rubber-tired units or crawler type tractors.

Scrapers, as a rule, are not used to any great extent in residence

building or on any work in congested city areas but for jobs such as suburban and rural schools, hospitals, factories, housing projects, in fact any construction work with a medium to large site grading problem, scrapers are probably the most efficient pieces of excavating equipment for the job.

The scrapers can be used to strip and stockpile top soil, after the site has been cleared, at the beginning of the job and they can reclaim the top soil from the stockpile and spread it where required at the end of the job. Many times basement excavation may be carried on in conjunction with site grading cuts and fills by scrapers.

The basic efficiency of scrapers is relatively unaffected by depth of cut, length of haul or type of soil. Quantities being sufficient to warrant the use of scraper equipment, crawler tractor drawn scrapers are economical at haul distances up to 500 feet and with rubber-tired, high speed prime movers can compete with trucks on longer hauls.

Capacities of scrapers range from about 7 cu. yds. struck measure to approximately 40 cu. yds. heaped measure.

Scrapers powered by crawler tractors are capable of self-loading in most soils but generally it is more economical to use pusher assistance from a tractor to obtain heaped loads in the shortest time. With few exceptions, pusher assistance is essential for self-propelled, rubber-tired scrapers. Pusher loading is generally accomplished in an average of about 1 minute in 100 ft. of travel. To determine the number of scrapers one pusher can handle, divide the scraper cycle by the pusher cycle.

Estimating the Cost of Owning and Operating Tractors and Scrapers.—In order to properly prepare an estimate on work to be done by tractors and/or scrapers, the contractor must know what to charge for the use of the equipment. He should work out an hourly charge for the equipment, to be used in pricing his estimates, so that the cost of ownership and operation is carried proportionately by each job and does not have to come out of profit.

Hourly Cost of Ownership.—The cost of ownership has as its basis the total delivered cost of the piece of equipment and is composed of several items, namely, depreciation, interest, insurance and taxes.

In figuring the hourly depreciation cost most contractors usually take the full delivered price of the machine, less cost of tires, and divide by the expected economic life of the machine in hours. The life expectancy figure commonly accepted is 5 years of 2,000 hours each or 10,000 hours.

Interest, insurance and taxes are computed on the basis of average investment. The average investment in a piece of equip-

ment which is to be fully depreciated in 5 years is 60 percent of the full delivered cost, as is shown on previous pages under Power Shovels and Cranes. The accepted rate for interest is 6 percent, insurance 2 percent and taxes 2 percent making a total of 10 percent which, when applied to the average investment and then divided by 2,000 hours, amounts to .003 percent of the full delivered cost and gives the hourly cost of interest, insurance and taxes.

Total hourly ownership cost is then obtained by totaling the hourly cost of depreciation and the hourly cost of interest, insurance and taxes.

Hourly Cost of Operation.—This cost includes tire replacement, tire repairs, fuel, lubrication, mechanical repairs, maintenance of blades and cable and wages of operator.

The hourly costs of tire replacements and tire repairs are computed in the same manner as previously described, under "Hourly Cost of Ownership and Operation of Motor Trucks", and are based on a tire life of 3,000 hours of operation with repair costs assumed to be 15 percent of the hourly tire cost.

Fuel costs may be figured on the following basis: Assuming an average machine in good repair, operating under average conditions, gasoline consumption should be approximately 0.06 gallons per horsepower hour and diesel fuel consumption about 0.04 gallons per horsepower hour.

Experience has shown that lubricants and lubricating labor amount to approximately 50 percent of the fuel costs per hour.

Cost of repairs and maintenance, including major overhauls at the end of the working season, should be determined by the contractor from his own experience record.

Many contractors find that total repairs, maintenance and overhauls for the economic life of the machine runs from 70 percent of the full delivered price for the larger machines to 90 percent for the smaller machines.This percentage divided by the economic life of the machine in hours, 10,000, will give the hourly cost of mechanical repairs, maintenance, etc., and amounts from .007 percent to .009 percent of the total delivered cost.

The hourly cost of maintenance of blades and cables is figured separately from the cost of general maintenance and repair as this item will vary depending on the soil conditions encountered. This cost may be estimated by dividing the replacement cost of blades and cables by their expected life in hours. Under average conditions this life may be expected to be about 450 hours; under favorable conditions, such as digging soft loam, etc., this life may be increased to about 800 hours; under unfavorable conditions, where sharp rocks and shale are

being loaded, the expected life should be reduced to about 250 hours.

Wages of the operator vary with the locality but are easily determined.

Approximate Prices of Crawler Type Tractors with Bulldozer Equipment

Horsepower	Weight in Lbs.	Approximate Price F.O.B. Factory
50	9,800	$ 8,100.00
66	13,000	11,200.00
89.5	22,000	16,200.00
124	30,000	20,000.00
190	45,000	30,500.00

Approximate Prices of Crawler Type Tractor Shovels

Capacity in Cu. Yds.	Horsepower	Approximate Price F.O.B. Factory
1	55	$11,000.00
1½	71	14,500.00
2¼	95	20,600.00
3	134	27,200.00

Approximate Prices of Self-propelled Scrapers

Capacity in Cu. Yds. Struck	Heaped	Horsepower	Approximate Price F.O.B. Factory	Original Tire Value
7	9	148	$ 33,000.00	$ 5,000.00
15	21	318	63,000.00	14,000.00
25	34	475	106,000.00	21,000.00

Approximate Prices of Tractor-Elevating Scrapers

Capacity in cu. yds.	Horsepower	Approximate Price F.O.B. Factory	Original Tire Value
11	160	$ 36,900	$ 6,300.00
21	318	75,400	15,000.00
32	475	114,300	21,400.00

Data on Cost of Ownership and Operation of Bulldozers, Tractor Shovels and Scrapers.—The following data gives the hourly cost of ownership and operation for various sizes of tractor and scraper equipment and is based on the preceding price and horsepower information. It does not include operator's wages, supervision, compensation and liability insurance or Social Security taxes.

Hourly Cost of Crawler Type Bulldozers

Horsepower	50	66	89.5	124	190
Approx. Delv'd. Cost.	$8,400	$11,600	$16,700	$20,700	$31,500

Depreciation, .01%..	$0.84	$1.16	$1.67	$2.07	$3.15
Interest, Insurance and Taxes. .003%.....	0.25	0.35	0.50	0.62	0.95
Fuel, .04 Gal. per HP*	0.40	0.52	0.71	0.99	1.52
Lubrication, Including Labor, 50% of Fuel	0.20	0.26	0.36	0.50	0.76
Mech. Repairs and Maintenance, .007%	0.59	0.81	1.17	1.45	2.20
Blade and Cable Replacement	0.19	0.20	0.23	0.25	0.29
Total Hourly Cost†..	$2.47	$3.30	$4.64	$5.88	$8.87

Hourly Cost of Crawler Type Tractor Shovels

Bucket Capacity, Cu. yds.	1	1½	2¼	3
Horsepower	55	71	95	134
Approx. Delv'd. Cost $11,300		$14,900	$21,200	$27,800
Depreciation, .01%	1.13	1.49	2.12	2.78
Interest, Insurance and Taxes, .003%.....	0.34	0.45	0.64	0.83
Fuel, .04 Gal. per HP.*....	0.44	0.56	0.76	1.08
Lubrication, Including Labor, 50% of Fuel.....	0.22	0.28	0.38	0.54
Mech. Repairs and Maintenance, .007%.....	0.79	1.04	1.48	1.95
Blade and Cable Replacement	0.19	0.20	0.23	0.25
Total Hourly Cost †	$3.11	$4.02	$5.61	$7.43

Hourly Cost of Self-propelled Scrapers

Capacity, Struck in Cu. Yds. ..	7	15	25
Capacity, Heaped in Cu. Yds. ..	9	21	34
Horsepower	148	318	475
Approx. Delv'd. Cost $33,000.00		$63,000.00	$106,000.00
Original Tire Value	5,000.00	14,000.00	21,000.00
Depreciation, .01% of Total Investment Less Tires ..	2.80	4.90	8.50
Interest, Insurance and Taxes, .003% of Total Investment ..	0.84	1.89	3.18
Tire Replacement, 3,000-Hr. Life	1.67	4.67	7.00
Tire Repairs, 15%	0.25	0.70	1.05
Fuel, .04 Gal. per Hp.*	1.18	2.54	3.80
Subtotal	$6.74	$14.70	$23.53

*Based on 20 cts. per gallon for diesel fuel.
†Not including Labor, Supervision, Unemployment, Soc. Sec., Overhead Expense

Brought Forward	$6.74	$14.70	$23.53
Lubrication, Incl. Labor, 50% of fuel	.59	1.27	1.90
Mech. Repairs and Maintenance, .007% of Total Investment ..	2.31	4.41	7.42
Blade and Cable Replacement	0.33	0.41	0.62
Total Hourly Cost †	$9.97	$20.79	$33.47

Hourly Cost of Tractor Elevating Scrapers

Capacity, in Cu. Yds.	11	21	32
Horsepower	160	318	475
Approx. Delv'd. Cost	$38,000.00	$77,000.00	$116,000.00
Original Tire Value	6,300.00	15,000.00	21,400.00
Depreciation, .01% of Total Investment Less Tires	3.17	$6.20	$9.46
Interest, Insurance and Taxes, .003% of Total Investment ...	1.14	2.31	3.48
Tire Replacement, 3,000-Hr. Life	2.10	5.00	7.13
Tire Repairs, 15%	0.32	0.75	1.07
Fuel, .04 Gal. per Hp.*.....	1.28	2.54	3.80
Lubrication, Incl. Labor, 50% of Fuel	.64	1.27	1.90
Mech. Repairs and Maintenance, .007% of Total Investment ...	2.66	5.39	8.12
Blade and Cable Replacement ..	0.35	0.45	0.85
Total Hourly Cost †	$11.66	$23.91	$35.81

*Based on 20 cts. per gallon for diesel fuel.
†Not including Labor, Supervision, Unemployment, Soc. Sec., Overhead Expense

Bulldozer Production

In an average day's work, the bulldozer may be called upon to do several of the many operations it is capable of and therefore time will be lost in moving from one task to another. This time loss must be considered in estimating bulldozer work or the job may not be profitable. Inasmuch as each job has its own peculiar problems, no table can be set up which will reflect the time losses to be experienced and the estimator must analyze each job carefully and adjust the production rates to conform to the conditions present.

The following table gives the approximate hourly production to be expected from various sized bulldozers and is based on having good weather conditions, efficient, well-maintained machinery and steady operation. It has been established that a well organized and supervised job will result in approximately 50 work-productive minutes each hour or a job efficiency of 83 percent.

Approximate Hourly Production of Bulldozers

Based on a Job Efficiency of 83 Percent

Description of Work	Horsepower 50	66	89.5	124	190
Simple clearing, vegetation, light brush, tree saplings, in sq. ft. per hour.	900 to 1,000	1,000 to 1,100	1,150 to 1,250	1,250 to 1,350	1,450 to 1,550
Moderately difficult clearing, thick brush and tree saplings, in sq. ft. per hour. Add extra for trees.	300 to 350	350 to 400	400 to 450	600 to 650	700 to 750
Strip top soil or shallow excavation of ordinary soil and placing in piles on premises, in cu. yds. per hour.	15 to 20	17 to 22	20 to 25	22 to 27	27 to 32
Backfill, ordinary soil placed slow enough to permit puddling, in cu. yds., per hour.	33 to 38	37 to 42	43 to 48	50 to 55	60 to 65
Spread material dumped in piles by trucks or cast by other excavating equipment, in cu. yds. per hour.	42 to 47	45 to 50	55 to 60	60 to 65	70 to 75

Scraper Production

Relative scraper production is mainly governed by the cycle time of operation, that is, the length of time a scraper will take to load, haul, spread-dump and return to start over again. In properly organized jobs with good, adequately powered equipment, a portion of this cycle is usually termed the fixed time because it is relatively unaffected by the length and grades of the haul and consists of the following: loading, approximately 1.0 to 1.5 minutes, spread-dumping, about 0.5 minutes, two turns of 0.25 minutes each, and shifting and acceleration of 0.5 to 1.0 minute or a total fixed time of 2.5 to 3.5 minutes. The other part of the cycle is the actual time of hauling the load to the fill area plus the time of returning empty to the beginning of a new cut. This traveling time is the big variable in the operation as it is affected by length of haul, road conditions and grades to be negotiated and must be estimated accurately. Scrapers powered by rubber-tired tractors can reach a speed of 30 m.p.h. when empty and on a good level road but this will often be reduced to 10 to 20 m.p.h. when loaded. It must also be remembered that adverse grades will greatly reduce the speed and on the other hand favorable grades will increase the speed. The traveling time plus the fixed time will be the cycle time of operation.

Yardage production should be figured in terms of bank measure.

Therefore, when estimating scraper production, the struck capacity of the machine is usually used as the pay yardage volume, anticipating the scraper to be heap loaded. The difference between struck and heaped capacity is generally assumed to be the amount the material will swell in being disturbed.

The following table gives the daily scraper production for various sized machines operating at several different time cycles and is based on ordinary soil conditions, good weather, good equipment and an 83 percent job efficiency.

Daily Scraper Production for Various Operation Cycles Based on a 50-Minute Hour and an 8-Hour Day

Operation Cycle in Minutes	Struck Capacity of Scraper in Cu. Yds.			
	7	14	24	32
3	930	1860	3200	4260
4	700	1400	2400	3200
5	560	1120	1920	2560
6	465	930	1600	2130
7	400	800	1370	1830
8	350	700	1200	1600
9	310	620	1070	1420
10	280	560	960	1280

Specimen Estimate for Scraper Excavation

Based on a site grading cut containing 8,000 cu. yds., excavated material to be spread-dumped in low areas requiring fill, good conditions permitting a 50-minute hour, an operation cycle of 6 minutes and using two 12 cu. yd., struck measure, self-propelled scrapers.

Bringing Scrapers to Job	Hours	Rate	Total	Rate	Total
Trucks and Trailers	16	$.....	$.....	$10.50	$ 168.00
Foreman	8	.....	.....	7.00	56.00
Scraper operators	16	.....	.....	6.75	108.00
Excavating					
Foreman	40	.....	.....	7.00	280.00
Scraper operators	80	.....	.....	6.75	540.00
Removing Scrapers at Completion					
Trucks and Trailers	16	.....	.....	10.50	168.00
Foreman	8	.....	.....	7.00	56.00
Scraper operators	16	.....	.....	6.75	108.00
Scraper charges	112	.....	.....	11.25	1260.00
Total Direct Cost	312		$.....		$2744.00
Compensation and Liability Insurance			.....		38.00
Old Age Benefit and Unemp. Comp.			.....		42.00
Overhead expense and profit			.....		1412.00
Total Cost			$.....		$4236.00
Cost per cu. yd.			.....		.53

If a 124-Hp. bulldozer would be required to give pusher assistance in loading, to maintain the operation cycle time of 6 minutes, the additional cost per cu. yd. would be as follows:

Hauling Bulldozer to and from Job	Hours	Rate	Total	Rate	Total
Truck and Trailer.....	16	$.....	$.....	$10.50	$ 168.00
Bulldozer operator	16	.....	.....	6.75	108.00
Excavating					
Bulldozer operator	40	.....	.....	6.75	270.00
Bulldozer charge	56	.....	.....	5.70	319.20
Additional Direct Cost	.128		$.....		$865.20
Compensation and Liability Insurance					13.00
Old Age Benefit and Unemp. Comp.					16.00
Overhead expense and profit			.....		447.10
Additional Cost			$.....		$1341.30
Additional cost per cu. yd..			$.....		.167

Supervision, overhead expense and profit may vary from 25% to 50%, depending upon size of job, degree of risk, desirability of work, etc.

Pouring Concrete Using a Crane and Bucket.

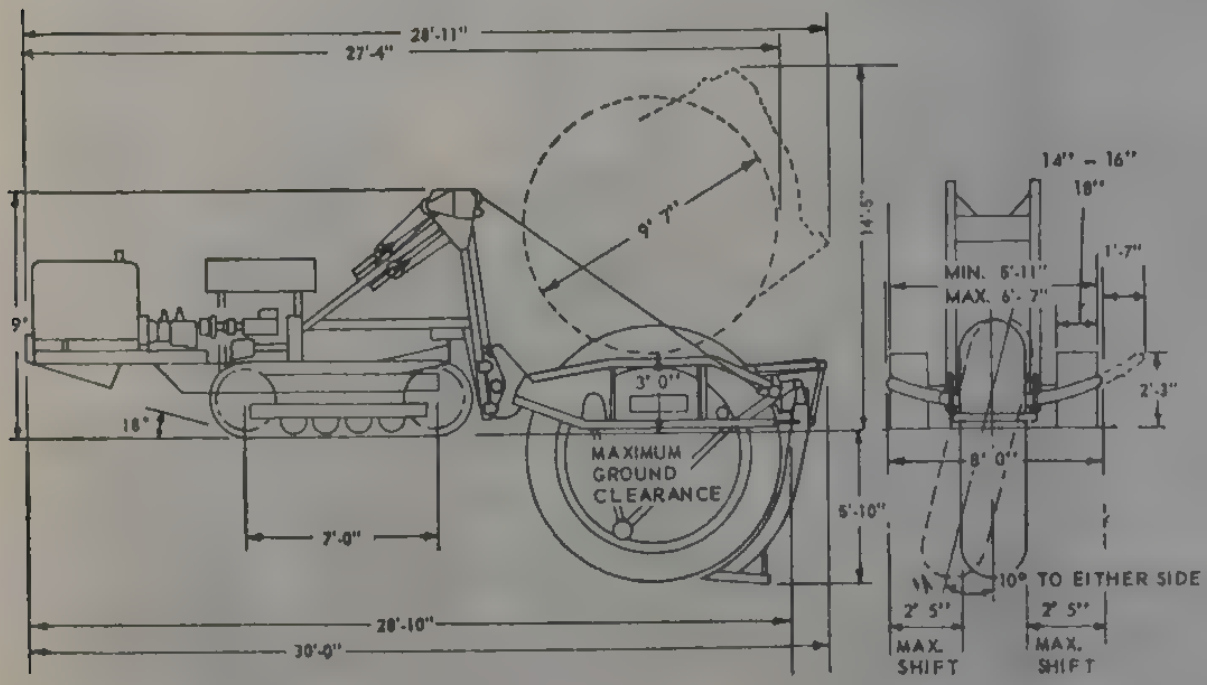
Wheel Ditcher with Portable Conveyor Attached for Loading Directly into Trucks

Trenching and Ditching Machine Excavation

To quote a well-known trenching contractor, "Designed strictly for the one purpose of cutting ditches, the trenching machine, when properly applied, is the fastest earthmover for its weight and horsepower in the construction field. Before a contractor can reap the benefits of this great potential output, he must first select a trenching machine of a type and size which fits the work to be done and, even more important, must put on the machine an operator who possesses both skill and mechanical knowledge."

There are three basic types of machines, the wheel type, the ladder type and the vertical boom type. The wheel type is generally considered to be the fastest and is by far the most common type in use today. Although the vertical boom type is no longer manufactured, there are still many in use. Each type has advantages and disadvantages for performing certain classes of work.

Inasmuch as most trenching or ditching operations in connection with building construction will be foundations, service trenches, etc., the following data covers the cost and operation of a general purpose, crawler mounted, wheel machine of the type and size generally used for this work.



Dimensions of Crawler Mounted Wheel Ditcher

This machine is equipped with shifting-tilting boom that permits it to dig close to obstructions, such as foundations or curbs, and to dig a vertical trench even when machine is on a slope.

The cost of excavating using a trenching or ditching machine will vary with the size of the job, width and depth of trenches, kind of soil, accessibility, etc. Most machines are designed to dig certain standard width trenches, so that trenches a trifle narrower or wider will not make any appreciable difference in either output or costs.

While the following table gives the rated capacity of the machine, it will be necessary to allow a factor of safety for time lost moving machine, bad weather, time lost due to waiting for trucks when excavated materials must be loaded, etc., so it is not advisable to figure rated capacity as the average daily output of any machine.

Data on Crawler Mounted Ditching Machine Operation and Cost

Wheel Size	Possible Cutting Widths	Maximum Depth Trench	Weight in Pounds	Approx. Cost F.O.B. Fcty.	Lin. Ft. Trench Dug per Hr.
10"x9'-7"	14"	5'-10"	22,000	$28,000	900
16"x9'-7"	24"	5'-10"	25,380	$29,000	600

Maximum digging speed is 34 f.p.m. Forward and reverse travel speeds are 0.46, 0.95, 1.7 and 2.9 m.p.h.

Digging speeds are controlled by a hydraulic transmission, permitting speed to be infinitely varied to match soil conditions. Wheel speeds are infinitely variable from 0 to 9.2 r.p.m.

Crawler Mounted Ditching Machine Operation and Cost

When figuring operating cost on a ditching machine, in
fuel and oil consumption, depreciation, interest on investme
pairs, replacements, taxes, etc.

Description	Digging Wi 12"	
Approximate Delivered Price	$28,000	$29,0
Depreciation per year, 18%	5,040	5,2
Interest 8% per year	2,240	2,320
Insurance and Taxes per year, 5%	1,400	1,450
Repairs and Replacement per year, 10%	2,800	2,900
Hourly Consumption of Fuel, Gal.	5	6
Daily Cost of Fuel, Oil, Grease, 40 cts. gal. + 15%	18.40	22.08

Operating Cost per Mile (Based on 75 Mi. per Year, 200 Working Days per Year, Avg. Trench Depth, 5'-0")

Depreciation	$ 67.20	$ 70.27
Interest	29.87	30.93
Taxes and Insurance	18.67	19.33
Repairs and Replacements	37.33	38.67
Fuel, Oil and Grease	34.69	41.60
Total machine cost per mile	$187.76	$200.80
Machine cost per lin. ft. trench	.0355	.0378

Cost of Digging 100 Lin. Ft. of Trench 5'-0" Deep, Using a Crawler Mounted Ditching Machine, Based on 350 Lin. Ft. per Hour

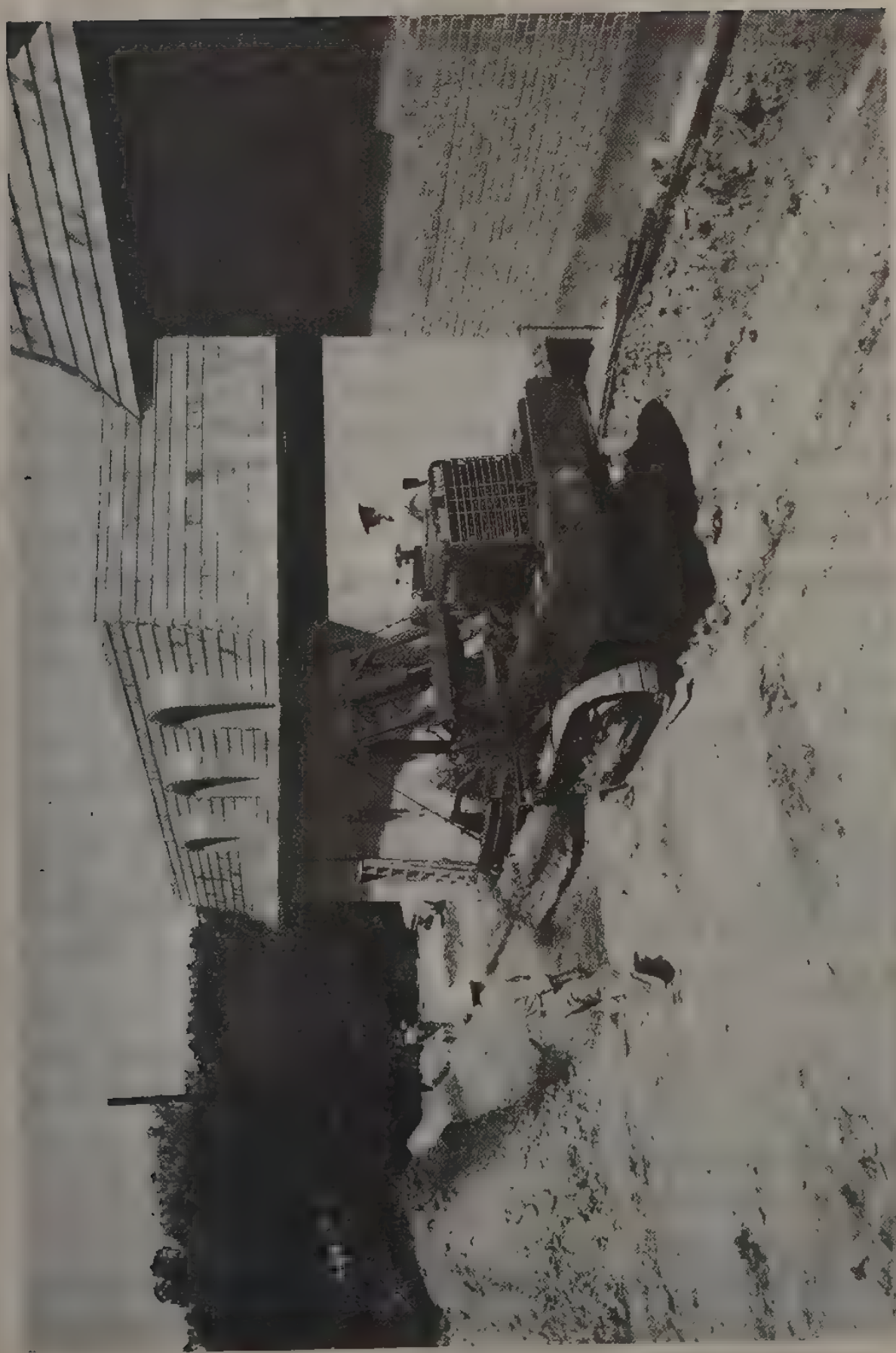
	Hours	Rate	Total	Rate	Total
Machine operator	0.29	$.....	$.....	$6.75	$1.96
Machine charge, 12" wide		.....	.....	.0355	3.55
Machine charge, 24" wide		.....	.....	.0378	3.78
Cost per 100 lin. ft., 12" wide					5.51
Cost per 100 lin. ft., 24" wide					5.74
Cost per lin. ft., 12" wide					.055
Cost per lin. ft., 24" wide					.057

To the above, add cost of trucking machine to job and removing same at completion, supervision, compensation and liability insurance, Social Security and Unemployment taxes, overhead expense and profit. Add for backfilling trenches, if required.

Volume of Trench Excavation

Cu. Yd. per 100 Lin. Ft.

Trench depth, in.	Trench width, in. 12	18	24	30	36	42	48
12	3.7	5.6	7.4	9.3	11.1	13.0	14.8
18	5.6	8.3	11.1	13.9	16.7	19.4	22.3
24	7.4	11.1	14.8	18.5	22.2	26.0	29.6
30	9.3	13.8	18.5	23.2	27.8	32.4	37.0
36	11.1	16.6	22.2	27.8	33.3	38.9	44.5
42	13.0	19.4	30.0	32.4	38.9	45.4	52.0
48	14.8	22.2	29.6	37.0	44.5	52.0	59.2
54	16.7	25.0	33.3	41.6	50.0	58.4	66.7
60	18.6	27.8	37.0	46.3	55.5	64.9	74.1
66	...	30.5	40.7	51.0	61.0	71.3	81.6
72	...	33.3	44.5	55.5	66.7	77.9	89.0
78	...	36.0	48.1	60.2	72.2	84.2	96.5
84	...	38.9	51.9	64.8	77.8	90.8	104.0
90	...	41.6	55.6	69.5	83.4	97.3	111.4
96	...	44.4	59.2	74.0	88.9	102.0	118.6



Crawler Mounted Wheel Ditcher with Shifting-Tilting Boom

Drilling Holes Using an Earth Boring Machine.—Where a large number of holes are required for line construction, foundation work, pre-boring, guard rails, piling, fencing, draining, bridges, etc., an earth boring machine will perform the work much faster and at lower cost than most other methods.

These machines will drill holes through loam, clay, hard pan and shale and are furnished in various sizes by different manufacturers. Some machines will drill up to 8'-0" diameter holes to a depth of 120 ft. or more.

When drilling holes up to 18" in diameter in ordinary soil, a machine will drill at the rate of 1" depth in 1½ to 2 seconds, or drill a 3'-0" deep hole in 1 to 1¼ minutes. Moving the machine and spotting the holes takes some time, so this will govern the number of holes that may be drilled per day.

A machine that will drill holes to 24" diameter and 9'-0" deep costs approximately $8,000.00 f.o.b. factory. This does not include cost of truck, which will have to be added. The larger machines which are used for drilling caisson foundations may cost as much as $100,000.00.

Based on 20 holes, 18" diam. and 3'-0" deep, an hr. or 160 holes per 8-hr. day, the daily cost should average as follows:

	Hours	Rate	Total	Rate	Total
Operator	8	$....	$....	$6.75	$54.00
Machine charge	8	....	....	5.00	40.00
Truck charge	8	....	....	4.60	36.80
Total cost 240 holes	8	....	$....		$130.80
Cost per 3'-0" hole			....		.817
Cost per lin. ft.			....		.272

If this work is sublet to a contractor specializing in this class of work, add 30 to 50 percent to the above prices for supervision, overhead expense, insurance, and profit.

There is also a small portable post hole digger, mounted on two rubber tired wheels and equipped with a 5 to 6 h.p. gasoline engine.

This machine can be operated by one man and in ordinary ground it will bore a 9" hole 3'-0" deep in 1 to 1½ minutes. Such a machine costs $700.00 to $800.00.

Placing and Compacting Fills

In recent years architects and engineers, in general, have become more rigid in their requirements as to the manner of placing and compacting fill materials. The usual specification for this work is to place the fill in from 6 to 12 inch layers and to compact each layer with some sort of roller equipment.

Placing and Compacting Site Grading Fills.—Fill material in site grading work is placed either by scrapers spread-dumping their loads, trucks dumping their loads more or less in piles or some sort of excavating equipment casting dipper or bucket loads as they are dug. In the case of the scraper spread-dumping fill material no further spreading is necessary as this can be controlled with precision by the scraper operator. In the other cases, however, a bulldozer will be required to spread out the fill material into layers of specified depth and hourly production for this work may be found in the table under "Bulldozer Production."

When the fill has been placed and spread in the specified depth of layer, the compacting operation follows and this is usually accomplished by rolling with a tractor drawn sheepsfoot roller. The degree of compaction may be specified by the number of passes to be made by the roller or by a percentage, such as 95%, of maximum density of the material obtained at optimum moisture content in a soil mechanics laboratory. The latter specification is usually called for in government work and for fills under paving. To obtain 95 percent of maximum density compaction may take as many as 12 passes of a sheepsfoot roller. On ordinary jobs, however, 4 to 6 passes of the roller are usually called for to stabilize the fill.

If rolling is not to interfere with production schedules, a rate must be established in cubic yards compacted per hour and applied to the rate of placing and spreading the fill material to determine the size and number of rollers required to keep the job moving. Where frequent turns are made or restricted areas require maneuvering these factors must be considered and the figures adjusted accordingly.

The following table gives rate of compaction, in cu. yds. per hr., for rolling fill with a 5′-0″ wide sheepsfoot roller at 2.5 m.p.h. with the fill material placed in 12″ layers for soil of various compaction factors and for 1 pass of the roller to 12 passes.

Rate of Sheepsfoot Roller Compaction in Cu. Yds. per Hr. Based on 5'-0" Wide Roller, 2½ M.P.H. Speed, 12" Fill Layers and 100% Job Efficiency

Number of Passes of Roller	Percentage Factor of Pay Yd. to Loose Yd. Hard, Tough Clay 70%	Medium Clay 80%	Loam 90%
1	1,711	1,956	2,200
2	856	978	1,100
3	570	652	733
4	428	489	550
5	342	391	440
6	285	326	367
7	244	279	314
8	214	245	275
9	190	217	244
10	171	196	220
11	156	178	200
12	143	163	183

For rollers of different widths adjust the above rates proportionately, that is, for 10'-0" wide roller double the rates, for 15'-0" wide roller triple the rates, etc.

For different depths of layers adjust the above rates proportionately, that is, for 6" layers reduce the rates to ½, for 9" layers reduce the rates to ¾, etc.

The above rates must also be adjusted to normal job efficiency and further adjusted to take care of lost time in maneuvering and turning. In small jobs as much as 10 percent of the time could be lost in turns, etc.

Example: Assume a fill, placed in 9" lifts, to be rolled 8 passes with a double drum sheepsfoot roller 10'-0" wide at 2.5 m.p.h. in soil with a compaction factor of 80 percent.

From the table, 8 passes in 80% material will compact 245 cu. yds. per hr. Adjusting this rate for a 10'-0" wide roller gives a rate of 490 cu. yds. per hr. and further adjusting for 9" fill layers results in a compaction rate of 368 cu. yds. per hr. Assuming that a 50-minute hour or a job efficiency of 83% is expected, the rate is reduced to 305 cu. yds. per hr. and with a time loss of 10% anticipated for turns and maneuvering the final result is a compaction rate of 275 cu. yds. per hr.

The approximate cost for compacting fill at rate of 275 cu. yds. per hr. is as follows:

	Hours	Rate	Total	Rate	Total
Hourly charge for 89.5-Hp. bulldozer with double drum sheepsfoot roller.....	1	$....	$....	$5.60*	$5.60*
Bulldozer operator	1	....	....	6.75	6.75
Cost of Compacting 275 Cu. Yds.	1	....	$....		$12.35
Cost per cu. yd.			$....		.045

*Does not include hauling equipment to and from job, compensation and liability insurance, Soc. Sec. taxes or overhead and profit.

The sheepsfoot roller method of compaction is applicable to all soils with cohesive qualities, such as loams and clays, and in very dry soils it may be necessary to add moisture to the material to obtain the correct degree of plasticity.

With non-cohesive materials, such as sands and gravels, the sheepsfoot roller usually is ineffective and rubber-tired pneumatic rollers are used instead at approximately the same cost.

Placing and Compacting Fills for Floors on Ground Inside Buildings.—Fill material, necessary to raise the elevation of the subgrade for floors inside buildings, may be placed in a number of ways.

For small jobs this is usually done after the building is enclosed, the fill being brought in through door and window openings where it is then spread and tamped by hand. Three laborers working together should spread and tamp 35 to 40 cu. yds. of fill per 8-hr. day at the following cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.6	$....	$...	$5.00	$3.00

On larger jobs it may be possible to truck the fill material directly into the space and spread-dump it, using a small bulldozer to further spread into even layers. Compaction of material in this case can usually be accomplished by using a single drum sheepsfoot roller or small pneumatic roller for the open areas and by hand tamping at walls and columns. Trucking traffic over the various layers of fill is a big help in compacting the material.

The roller can be drawn by the same bulldozer that spreads the material and with 2 laborers spreading and tamping at "hard-to-get" places a daily production of 95 to 100 cu. yds. placed and compacted should be realized at the following cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
50-Hp. bulldozer and single drum sheepsfoot roller	0.08	$.....	$.....	$4.05*	$0.33*
Bulldozer operator	0.08	.....	.....	6.75	.54
Labor	0.16	.....	.....	5.00	.80
Cost per Cu. Yd.	0.24		$.....		$1.67

*Does not include hauling equipment to and from job, compensation and liability insurance, Soc. Sec. taxes or overhead and profit.

Grading

Grading consists of dressing up ground surfaces, either by hand or machine, to conform to specified contours or elevations and is usually preparatory to a subsequent operation such as placing a floor slab, walk or drive, spreading top soil for planting areas, etc.

Grading costs vary according to the degree of accuracy demanded and the method by which it is done. Following are approximate costs on some of the various types of grading usually encountered in construction work.

Rough Grading.—After all backfill is in place and the site has been cut and, or filled to the approximate specified contours, rough grading of the site is done, by hand for small jobs and by machine for large areas, usually preparatory to the spreading of top soil. Tolerance for this type grading is usually plus or minus 0.1 ft.

On small jobs a laborer should rough grade from 900 to 1,000 sq. ft. of ground surface per 8-hr. day at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.85	$.....	$.....	$5.00	$4.25
Cost per sq. ft.					.043

On large jobs a bulldozer is usually employed to do rough grading and a laborer generally accompanies the machine to check the surface and direct the operation. An 89.5-hp. bulldozer should rough grade 6,500 to 7,500 sq. ft. per 8-hr. day at the following cost per 1,000 sq. ft.:

	Hours	Rate	Total	Rate	Total
89.5-Hp. bulldozer charge	1.15	$.....	$.....	$5.20*	$5.98*
Bulldozer operator	1.15	.....	.....	6.75	7.77
Labor	1.15	.....	.....	5.00	6.75
Cost per 1,000 sq. ft.	2.30		$.....		$20.50
Cost per sq. ft.			.....		.021

*Does not include hauling equipment to and from job, compensation and liability insurance, Soc. Sec. taxes or overhead and profit.

Grading for Slabs on Ground.—Grading for slabs on ground such as floors, walks, driveways, etc., usually is done by hand unless the job is quite large and can be organized so that some of the work is done by machine. This work generally must be done accurately with tolerances of no more than $\frac{1}{8}$" to $\frac{1}{4}$" allowed. A laborer should grade 500 to 600 sq. ft. per 8-hr. day at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	1.5	$.....	$....	$5.00	$7.50
Cost per sq. ft.			....		.075

For sloping surfaces add from 50 to 100 percent to the above cost depending on steepness of pitch.

Finish Grading of Top Soil.—After top soil has been spread over areas specified a finish grading operation, usually including hand-raking, must be performed prior to seeding or sodding. The tolerance on this work usually is plus or minus $\frac{1}{2}$ inch. A laborer should finish grade and hand-rake 600 to 700 sq. ft. per 8-hr. day at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	1.25	$.....	$.....	$5.00	$6.25
Cost per sq. ft.			.....		.063

For sloping surfaces, such as berms, ditch sides, etc., add 50 percent to the above cost.

Grading for Footing Bottoms.—When footing pits and trenches are dug by machine there is always cleanup, squaring and grading work to be done by hand and many contractors price this work by the sq. ft. of footing bottom. A laborer should clean up, square and grade 100 to 150 sq. ft. of footing bottom per 8-hr. day at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	6.5	$.....	$.....	$5.00	$32.50
Cost per sq. ft.		.....	.....		.33

WELLPOINT SYSTEM OF DE-WATERING

The following information on wellpoints for dewatering excavations is general information only. For specific applications consult a local de-watering contractor.

Wellpoint systems are well known for their ability to dewater pervious water bearing soils, such as sand and gravel, so that excavation and construction of foundations can proceed in the dry.

In addition, wellpoint systems are used extensively in such work as soil stabilization, pressure relief for dams and levees and for water supply for muncipalities and industrial plants.

A wellpoint system as used in construction work, usually consists of a series of properly sized wellpoints, surrounding or paralleling the area to be de-watered, connected to a header pipe by means of risers and swing piping. Header piping, in turn, is connected to one or more centrifugal pumps depending on the volume of water which must be handled.

Wellpoints are usually self-jetted into place to the correct depth and at the proper spacing to meet the requirements. Some soil conditions, however, require pre-drilling or "hole-punching" before the wellpoints can be installed.

The discharge from the pumps should be piped to an area where it will not interfere with the construction work. The entire installation should be located so that it will interfere as little as possible with other divisions of the work.

Method of De-Watering Using Wellpoint System

This system is usually installed in advance of the excavation but where the water level is low it is sometimes possible that a portion of the digging may be done at a cheaper rate if it is done prior to the installation of the system.

Any de-watering problem which is beyond the scope of ordinary pumping, or which the contractor or engineer thinks can be done more economically with a wellpoint system, should be referred to the engineering department of a wellpoint company. In this way the problem will receive expert analysis, at no cost to the contractor or engineer. It is essential for most contractors to obtain expert advice on the layout and installation of wellpoint systems because frequently a relatively small excavation with unusual soil, presents greater de-watering difficulties than a larger, deeper job in a well-graded medium sand.

After carefully considering the various factors involved, including soil characteristics, site accessibility, hydrology of area, size and depth of area, total dynamic head involved, excavation and construction schedules, labor and working conditions, power facilities, etc., the wellpoint company can make a layout recommendation for the job.

Layout recommendations are usually accompanied by a quotation giving rental rates and charges for all equipment required, together with an estimate of the labor hours needed to install and remove the system, fuel and lubrication required per operating day, transportation charges for the equipment to and from the job and daily rates for salary and expenses of company demonstrator. Companies specializing in this type of work will furnish rental quotations on a "sufficient equipment" basis, i.e., a fixed rental rate regardless of the amount of equipment actually required to do the job. Some of these companies will submit lump sum contract proposals for de-watering projects covering furnishing, installation operation, maintenance and removal of all de-watering equipment with a guaranteed result.

It is sound practice to have a demonstrator from the wellpoint company on the job site to supervise the initial installation of the system. The cost of his time and expenses is more than compensated for by his working knowledge of wellpoint systems and their installation.

Operation of a wellpoint system is usually performed on a 24-hr. day, 7 day per week basis and must continue until all work, dependent on dry conditions, is completed.

The labor cost of operating the system must be determined by the contractor and is based on the length of time operation is estimated to be required, figuring around-the-clock operation.

From the above information the contractor or estimator should be able to arrive at a lump sum figure for the required wellpoint system to be used in his estimate.

As an example, take the case of a job in which an underground tank was to be constructed. The test borings indicated the soil to be sand with a ground water level at 6'-0" below the surface. The excavation for the circular tank was an average of 84'-0" in diameter and 18'-6" deep. To maintain dry conditions, the water level had to be lowered at least 12'-6". It was also estimated that a dry condition would have to be maintained for a period of 3 months.

A wellpoint company was consulted and the following specimen estimate is based on their quotation.

Equipment Rental, First Month	Hours	Rate	Total	Rate	Total
52 wellpoints, 2"		$	$	$ 6.90	$ 355.80
260 lin. ft. header pipe, 6"				.70	182.00
50 lin. ft. discharge pipe, 6"				.50	25.00
2 valves, 6"				10.00	20.00
1 wellpoint pump				385.00	385.00
1 jetwell pump*				360.00	360.00
Equipment Rental, Second Month					
52 wellpoints, 2"				$ 4.55	$ 236.60
260 lin. ft. header pipe, 6"				.30	78.00
50 lin. ft. discharge pipe, 6"				.25	12.50
2 valves, 6"				6.50	13.00
1 wellpoint pump				325.00	325.00
1 jetwell pump*				300.00	300.00
Equipment Rental, Third Month					
52 wellpoints, 2"				$ 3.00	$ 156.00
260 lin. ft. header pipe, 6"				.15	39.00
50 lin. ft. discharge pipe, 6"				.15	7.50
2 valves, 6"				5.00	10.00
1 wellpoint pump				300.00	300.00
1 jetwell pump				275.00	275.00
Carried Forward					$3,080.40

Installation of Equipment					
Brought Forward					$3,080.40
2 weeks rental, 200 lin. ft. jetting hose				$120.00	$ 240.00
Labor	160			4.00	640.00
Supervisor, 5 days				45.00	225.00
Supervisor's expenses				150.00	150.00
Operating Expense					
Diesel fuel 91 days at 40 gals. per day				.16	582.40
Lubricating oil, 91 days at 1 gal. per day				1.50	136.50
Pump operator, 3 shifts, regular time	1,560			5.00	7800.00
Pump operator, 3 shifts, overtime	624			10.00	6240.00
Removal of Equipment					
Labor	60			4.00	240.00
Transportation to and from job, 16,000 lbs. at $3.00 per cwt.					480.00
Total cost of wellpoint system	2,404		$		$19,814.30

Add for Insurance, Social Security, Unemployment Compensation, Overhead and Profit.

The jetwell pump is a double-duty unit and is connected into the system as a stand-by wellpoint pump after installation of wellpoints has been completed.

LANDSCAPING

While landscaping usually is not part of the contractor's work, some specifications include it, particularly government work. In cases of this sort the usual procedure is to sublet the work to a landscaping contractor.

For preliminary estimating purposes, however, the following information, based on the experience of a large Chicago area landscaping contractor, may be of some value.

The average price for seeding and fertilizing, including preparing the surface by disking or roto-tilling, grading and rolling, for small jobs, where much of the work is done by hand, ranges from 3½ to 4 cts. per sq. ft. For the same operation on large jobs, where most of the work is done by machine, the average price is from 2½ to 3 cts. per sq. ft.

Sodding may be done with either field sod or fine nursery sod and the operation includes preparing the surface as for seeding, fertilizing and rolling. For ordinary field sod the average price is

from $0.90 to $1.00 per sq. yd. and for fine nursery sod the average price is from $1.90 to $2.20 per sq. yd.

For common variety shrubs, such as Bridal Wreath, Forsythia, Common Lilac, etc., the average price for 4'-0" to 5'-0" high plants is from $3.50 to $4.00 each in place.

Trees may be had in various sizes and species. For common variety shade trees, such as Elm, Poplar, Maple, Oak, etc., the following average prices may be used. For bare root saplings, 2½" to 3½" in trunk diameter, the price is from $35.00 to $40.00 in place. For trees with trunk diameters from 4" to 8" and with the roots balled and burlapped the price ranges from $85.00 to $110.00 in place. Trees over 8" and up to 12" in diameter with balled and burlapped roots run from $275.00 to $300.00 each in place. Specimen trees, such as hawthorne, flowering crab, etc., from 6'-0" to 8'-0" high, cost $30.00 to $35.00 each in place.

Actual Costs of Excavating

Digging Fence Post Holes.—When digging 250 post holes about 3'-0" deep in black soil and sand, using an ordinary augur post-hole digger, a man dug 4 holes an hour or 32 per 8-hr. day, at the following labor cost per hole:

	Hours	Rate	Total	Rate	Total
Labor	0.25	$.....	$.....	$5.00	$1.25

Power Shovel Excavating under Favorable Conditions.—The following costs are for a theoretical job performed in early spring, where conditions were unusually favorable, with no time lost because of bad weather or break-downs during the two week period required to complete the work.

This is a basement excavation 80'-0" x 80'-0" and 13'-0" deep. The top 5'-0" consists of loose clay and loam, while the lower 8'-0" is blue grey dolomite limestone in beds varying from 6" to 24".

A ¾-cu. yd. Erie shovel will be used, rented at $18.40 per hr. including operator and fuel.

Four 4-cu. yd. trucks will transport the excavated earth and rock to a dump about ¼-mile from the job. Trucks cost $10.50 per hr. including gasoline and driver.

A 5½"x5" Ingersoll Rand portable air compressor, capacity 110 cu. ft. per minute and a Type 12 Standard I-R Jack-hammer is used for rock drilling. The rental of the compressor and jack-hammer, including gasoline, operator and repairs to drills is $9.00 an hour.

Excavating Loose Clay and Loam.—The area of loose clay and loam is 80'-0"x80'-0"x5'-0", a total of 1,190 cu. yds. of excavation.

The average on this job is 39 cu. yds. an hr. at the following labor cost per 100 cu. yds.:

	Hours	Rate	Total	Rate	Total
Shovel and Operator	2.5	$.....	$.....	$18.40	$45.00
Cost per cu. yd.....					$0.45

Four 4-cu. yd. trucks will haul 390 cu. yds. of excavated earth ¼-mile to a dump, or an average of 10 cu. yds. an hr. per truck, at the following cost per 100 cu. yds.:

	Hours	Rate	Total	Rate	Total
Truck and driver.....	10	$.....	$.....	$10.50	$105.00
Cost per cu. yd.....					1.05

Four men at the dump spread the excavated earth after it had been dumped by the trucks. Very little grading was necessary as the earth dump was a high-terraced fill around a building which required very little handling.

A man will spread about 10 cu. yds. an hr. at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.10	$.....	$.....	$5.00	$0.50

The total cost of excavating, hauling and spreading one cu. yd. of loose earth is as follows:

	Rate	Total
Shovel excavation	$.....	$0.45
Trucks hauling excavated earth	.....	1.05
Labor spreading loose earth at dump	.....	0.50
Cost per cu. yd.	$.....	$2.00

Rock Excavation

After the 5′-0″ of top soil has been removed, the excavation consists of blue grey dolomite limestone, hard, and stratified in beds varying from 6″ to 24″. The depth of the cut was 8′-0″, which was taken out in two lifts of 4′-0″ each. The last lift was drilled 5′-0″ deep or 1′-0″ below the desired level.

Total rock excavation is 80′-0″x80′-0″x8′-0″, or 1,900 cu. yds.

Drilling Rock for Blasting.—The area drilled is 80′-0″x 80′-0″, less a 5′-0″ border on 3 sides and a 10′-0″ border on one side. The rows were 5′-0″ apart and the holes were 5′-0″ on centers, staggered, and all of the holes will be 2″ in diameter.

There will be 14 rows with 15 holes in a row or a total of 210 holes, as follows: 210 holes 4′-0″ deep, containing 840 lin. ft. and 210 holes 5′-0″ deep, containing 1,050 lin. ft., at total of 1,890 lin. ft. of 2″ holes.

One man and a helper will drill 15 lin. ft. of 2″ hole an hr. or 120 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Compressor, jack-hammer and operator	7	$.....	$.....	$10.50	$73.50
Labor helping	7	.....	.....	5.00	35.00
Cost 100 lin. ft.	14		.....		$108.50
Cost per lin. ft.			.....		1.09
Cost per cu. yd.			.....		1.09

Explosives.—The job will require 5 cases (50 lbs. each) of 40% dynamite, a total of 250 lbs. which is equivalent to ⅛-lb. per lin. ft. of hole or per cu. yd. of excavation, and the cost of explosives was as follows:

	Hours	Rate	Total	Rate	Total
250 lbs. dynamite		$.....	$.....	$0.40	$100.00
425 electric detonators with 6′ wire lead		.....	.....	.22	93.50
150 lin. ft. No. 14, R.C.S.B. lead wire		.....	.....	.05	7.50
Total cost			$.....		$201.00
Cost per hole			.....		.48
Cost per lin. ft.			.....		.11
Cost per cu. yd. (1,900 cu. yds.)			.....		.11

Rock Excavation.—There will be 1,900 cu. yds. of rock excavation, taken out in two lifts of 4′-0″ each and the shovel will handle 17 cu. yds. an hr. at the following labor cost per 100 cu. yds.:

		Rate	Total	Rate	Total
Power shovel and operator	6	$.....	$.....	$19.00	$114.00
Labor*	6	.....	.....	5.00	30.00
Powderman	2	.....	.....	7.00	14.00
Labor assisting	5	.....	.....	5.00	20.00
Total cost 100 cu. yds.	19		$.....		$178.00
Cost per cu. yd.			.....		1.78

*One laborer on bull chain placing chain on rocks too large for shovel to handle.

Three 4-cu. yd. trucks hauled the excavated rock to a dump ½-mile from the job, averaging about 6 cu. yds. an hr. per truck, at the following labor cost per 100 cu. yds.:

	Hours	Rate	Total	Rate	Total
Truck and driver	17	$.....	$.....	$10.50	$178.50
Cost per cu. yd.			.....		1.79

Four men at the dump leveled 4½ cu. yds. of excavated rock an hr. at the following labor cost per 100 cu. yds.:

	Hours	Rate	Total	Rate	Total
Labor	22	$.....	$.....	$5.00	$110.00
Cost per cu. yd.			.....		1.10

The total cost of rock excavation, including drilling, blasting, excavating, hauling and spreading, averaged as follows per cu. yd.:

	Total	Total
Drilling	$.....	$1.09
Explosives	.....	.11
Excavating	.....	1.78
Hauling	.....	1.79
Spreading and leveling	.....	1.10
Cost per cu. yd.	$.....	$5.87

Bear in mind that the above work was performed under ideal conditions, which is not the case on most construction jobs.

Rock excavation conditions and costs vary widely. Always obtain information from sources at or near job site before bidding on this work. Check with one or more of the local powdermen —they will know what the conditions are and what production may be expected.

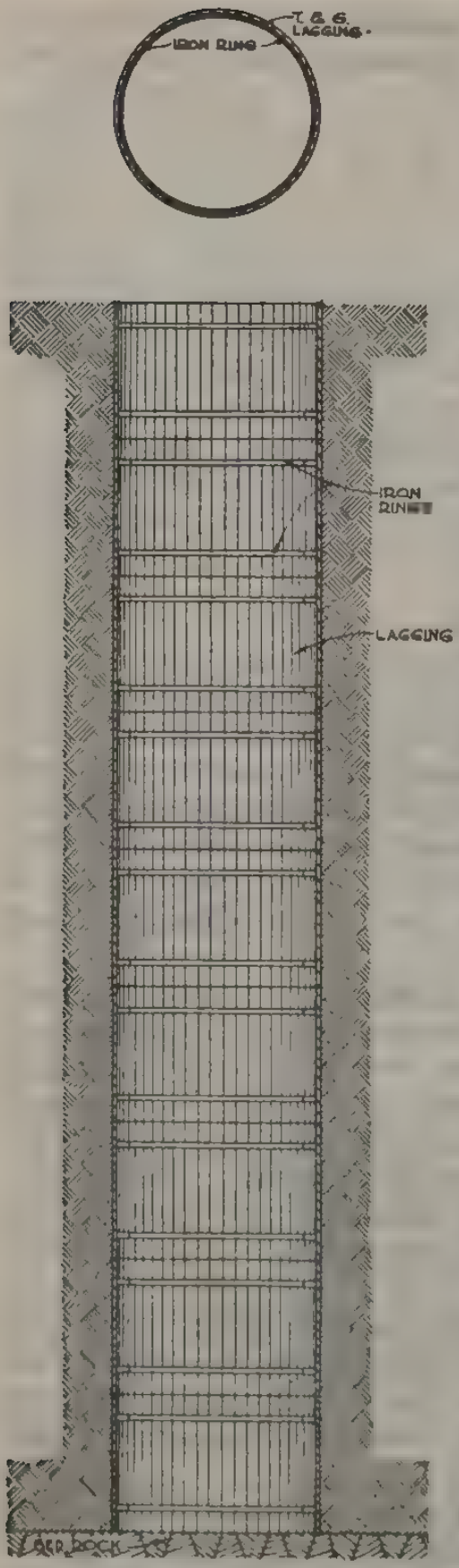
CAISSONS

Caisson foundations are ordinarily used to support heavy structures where soil conditions near grade are unsatisfactory for the support of them. Where such a condition exists the foundations should be carried down through the unsatisfactory soil to material capable of carrying the imposed load without causing any detrimental settlement. The size and depth of caissons will vary with the loads to be carried and the distance to material of the required bearing capacity. Caissons bearing on rock in the Chicago Loop area vary from 90 to 190 feet in depth.

Caissons may be dug either with straight shafts to the required depth, or they may be belled at their bottoms to provide additional bearing area. The majority of caissons are now being installed using various types of drill rigs but under certain conditions hand dug caissons may be used. The drilling machines are capable of not only drilling the shaft, but mechanically forming a bell as well. The cost of excavating varies with the diameter and depth of the caisson, the site conditions, and with the type of soil being excavated.

There are contractors who specialize in foundation work and the several types of caissons. On jobs of any size, it is advisable to obtain figures from these concerns covering the work, as they are equipped to perform it much more economically than the contractor who has only an occasional job.

Hand Dug Caissons.—The hand method of excavation most commonly used is known as the Chicago method. This consists of excavating with hand tools and lining the hole with wood lagging supported by steel rings. The wood lagging is beveled on the edges



Section Through Caisson Showing Lagging in Place.

and is tongue and grooved. The lagging is milled from either 2"x6" or 3"x6" mixed hard wood in 16' lengths. The 16' lengths are commonly cut into thirds so that a set of lagging is 5'-4" long. Three inch steel channels are formed in a half circle with a plate on each end to permit bolting the half sections together. Two complete rings are required for each set of lagging.

To determine the excavation quantity, multiply the cross-sectional area by the length allowing for the increased diameter due to the lagging. To determine the quantity of concrete required, multiply the cross-sectional area by lengths making proper corrections if the finished concrete surface is to be below the ground surface. If the caisson has a bell, the volume of it must be computed using the formula for a truncated cone—$(V = \frac{1}{3}(A_1 + A_2 + \sqrt{A_1 + A_2})\ h$ where $A_1 + A_2$ are the area of the bases and h is the height of the bell.

Excavation quantity for 6'-0" caisson 106' deep

Cross-sectional area for 6'-4" = 31.5 ft.^{2}

$31.5 \times 106 \times 1/27 = 124$ cu. yds.

Concrete quantity

Cross-sectional area for 6'-0" = 28.3 ft.^{2}

$28.3 \times 106 \times 1/27 = 111$ cu. yds.

Allow 5% for overbreak or a total of 117 cu. yds.

After determining the excavation quantities and the concrete quantities, it is then necessary to determine the amount of lagging and rings. By cutting the bevel and tongue and grooves in the lagging, the width of the lagging is reduced so that it requires 7

pieces per foot of diameter of the caisson. For example, a 4′ diameter caisson requires 28 pieces of lagging around the circumference. Therefore, using 2″x6″ lagging, which is one board foot, it would require 28 board feet per foot of depth for a 4′ caisson or 42 board feet using 3″ thick lagging. To determine the amount of lagging required in a 6′ diameter caisson, 106′ deep using 2″ lagging, multiply 6x7 or 42 board feet per foot of depth x the depth, which is 106″ or 4452 board feet. If the lagging had been 3″, it would be 6678. A caisson 106′ deep would require 20 sections of 5′-4″ lagging, using 2 rings for each sectional lagging. The caisson would require 40 rings.

These rings are generally made from 3″ channels, weighing 4.2 lbs. per foot or approximately 80 lbs. plus 10 lbs. for the plates at the ends of the half circles. For a total of 90 lbs., this type of material generally costs approximately 20c per pound or $18 per ring.

Labor Required for Caissons.—Labor costs of caissons excavating varies with the diameter and depth of caissons, whether hand or pneumatic tools are used, the type of soil, and whether or not water or sand is encountered. It is generally assumed that one caisson digger can dig approximately 4 to 5 yards per 8 hour shift and place rings and lagging.

Only one man can work in a 4′ diameter shaft; two men can work in a 5′ diameter or larger shaft. In a 6′ caisson, two men each taking out 4 yards should be able to excavate approximately 7′ per shift. At the surface, a pneumatic tugger hoist and tripod would be required with two laborers to operate the hoist and dump the buckets. Generally, several caissons are constructed simultaneously so the cost involved in furnishing compressed air is spread over three or more caissons.

In addition to the above, it will be necessary to allow for time of foreman, timekeepers, material clerks, engineers, cost of setting up and removing equipment, etc. which will cost from $2.00 to $3.00 per cu. yd. or it may be estimated separately under overhead expense and a certain amount allowed to cover the entire job.

To summarize the costs involved for constructing a caisson 6′ in diameter while two others are being constructed simultaneously:

Time to excavate and lag:

124 cu. yds. @ 4 cu. yds./shift/digger = 31 shifts.
Using two diggers, this would be 15½ shifts.
Allow 16 shifts.

Labor	Hours	Rate	Total	Rate	Total
Caisson diggers	256	$....	$.....	$ 5.40	$1,382.40
Hoist operator	128	....	.....	5.20	665.60
Top laborers	256	....	.....	5.00	1,280.00
Compressor operator	43	....	.....	6.00	258.00
					$3,586.00
Material					
Lagging	4.452MBF	....	.....	110.00	489.72
Rings	40	....	.....	20.00	800.00
					$1,289.72
Equipment					
Hoist	16 shifts	....	.....	3.00	48.00
Air tools	32 "	....	.....	4.00	128.00
Compressor	5-⅓ "	....	.....	16.00	85.33
					$ 261.33
Removal of					
Excavated soil	124 cu. yds.	....	.....	3.00	372.00
				Grand Total	$5,509.05
				Cost per cu. yd.	$ 44.40

To the above cost it will be necessary to add for setting up and removing necessary plant and equipment, electric current and wiring, concrete furnishing and placing, overhead expenses, contingencies, miscellaneous expenses, and profit.

Work of this type in the Chicago area generally costs from $90 to $120 per cu. yd. of completed caisson.

Drilled Caissons.—In the past 15 years or so, the use of drilling machines for the installation of caisson foundations has eliminated the hand digging method except in situations where adequate clearances to surrounding structures or utilities cannot be maintained. Drilled caissons have proved more economical than hand-dug caissons for several reasons, the most important of which is the fact that smaller shaft diameters may be used. The minimum size of a hand-dug caisson is 4′ in diameter, which oftentimes provides a much greater cross-sectional area of concrete than is required for the load imposed upon it.

Another important reason is that drilled caissons may be installed in considerably less time than is required for hand-dug caissons, thereby reducing overall construction time and allowing earlier occupancy of the completed building. There are many firms specializing in this type of work throughout the country.

A typical job consisting of 100 caissons with 2′-0″ shaft diameters, 5′-0″ bells and 25′ deep, might be estimated as follows, assuming normal clay digging. First, compute the total volume of excavation which in this case would be 418 cu. yds. To this figure add about 10% overbreak, making a total of 460 cu. yds. Assuming

Drilling Machine Digging Caisson

each drill rig can complete 5 caissons per day, the job would take 20 days. Allow approximately 10% extra time for weather and maintenance and one day for moving on and off the job making a total of 23 days to complete the job.

Labor	Hours	Rate	Total	Rate	Total
Drill Rig Operator	184	$....	$.....	$ 6.75	$1242.00
Oiler	184	....	.....	5.00	920.00
Caisson Laborer	184	....	.....	5.40	993.60
Laborer	184		.....	5.00	920.00
					$4075.60
Equipment					
Drill rig .....23 days		$....	$.....	$120.00	$2760.00
Material					
Concrete .....460 cu. yds.		....	.....	$16.00	$7360.00
		15% of Labor for insurance			611.34
					$14,806.94
		10% contingency			1,480.69
					$16,287.63
		10% overhead			1,628.76
					$17,916.39
		10% profit			1,791.64
					$19,708.03
		Cost per cu. yd. based on 418 cu. yds.....			$ 47.20

These costs are for the complete caisson installation. Allowances must be added for reinforcing steel, additional labor based on union requirements, temporary or permanent casings if necessary, soil and concrete testing, surveying, and disposal of excavated materials if these items are included in the caisson contractor's contract.

SUBSOIL INVESTIGATIONS

When preparing estimates on any structure involving foundations or earthwork, it is often necessary to make borings or test holes to ascertain the nature of soil which will be encountered at various depths below the ground surface, and to determine whether or not water will be found and at what depth. Frequently this information is shown on the working drawings to aid the foundation contractor in preparing his bid.

There are many methods used to investigate soil conditions for foundation purposes. Some are good while others produce inadequate or dangerously deceptive data.

Excavating test pits or caissons produces accurate information

in cohesive soils inasmuch as this method permits visual inspection of the soil in place and samples for laboratory tests may be carved out of the pit walls in a relatively undisturbed condition. Costs of this work are high, however, and will be about the same as excavating costs for comparable pits and caissons given on previous pages.

However, most subsoil investigations require studies of the soil at greater depths than can be economically reached by test pits. For these projects, various methods of soil boring and sampling are used by which a relatively small diameter hole is sunk into the ground from which soil samples are obtained.

Hand Auger Boring Method.—The hand auger boring method, satisfactory for highway explorations at shallow depths, can be used only for preliminary investigations for foundations. Auger borings are used in cohesive soils and cohesionless soils above ground water. Depths up to 20 feet may be reached. Soil samples obtained through this method are disturbed to such an extent that little or no information is furnished about the character of the soil in its natural state. Where the auger hole is filled with water, sample disturbance is particularly critical. Auger holes are most useful for ground water determination.

Hand auger borings generally costs from $1.50 to $3.00 per lin. ft. depending on the soil and the amount of boring necessary.

Split Spoon Sampling.—A split barrel sampler known as a split spoon is frequently used for obtaining representative samples. This method is described in detail in ASTM Method D-1586-67.

In securing split spoon samples, the drill hole is opened and cleaned to the desired sampling level by a fishtail drilling bit and wash water, or occasionally in cohesive soils by a power auger. Drill casing or drilling mud is used when it is necessary to prevent the soil above the sampling level from closing the drill hole. A drive pipe is attached to the upper end of the drill rod and a slip jar weight placed on the drive pipe.

The sampling spoon is then driven into the soil by repeated blows of a drop hammer. The number of blows required to drive the spoon are recorded on the logs. The spoon is then brought to the surface and the sample removed, classified and placed in a glass jar.

The ASTM method specifies a 2-inch OD x 1-⅜ inch ID split spoon driven 18″ to 24″ by a 140 lb weight falling 30 inches. Various other size split spoons, drop weights and length of drops are employed by some companies. The split spoon method is most useful in granular or dense soils.

Thin-Wall Tube Sampling.—The method of sampling which has

Subsoil Investigations

been found to give the least disturbed samples is the thin-wall tube method. These samples are most suitable for testing. This method is described in detail in ASTM Method D-1587-67.

In this method the hole is opened and cleaned as in the split spoon sampling method, but a thin-wall tube, usually with an outside diameter of 2″, 3″ or 5″ is then attached to the end of the drill rod and lowered to the bottom of the boring. The tube is then pushed into the soil by a hydraulic piston arrangement with a rapid and continuous motion.

The thin-wall tube is then raised to the surface, cleaned, labeled, and sealed to prevent loss of moisture. It is then taken to the laboratory for testing. Here it is usually cut into short lengths and the sample in each length ejected and tested.

Samples are taken at 5′ intervals or every time a soil change is expected as determined by watching the overflowing wash water and feeling the resistance to penetration of the drilling bit, irrespective of the distance between changes.

Cost of drilling and sampling is between $3.00 and $6.00 per lin. ft. depending on the quantity of work, plus on and off charges for the equipment and men. Laboratory testing is performed at an additional cost, usually in the range of $1.00 to $1.50 per foot of drilling for water content, density and unconfined compression tests.

Core Borings.—In addition to soil samples, information is frequently wanted on the nature or thickness of underlying rock. Core borings are made for this purpose with rotating coring tools such as diamond drills, shot drills, or carbide bits. Continuous samples are generally recovered for examination and further testing. ASTM Standard D-2113-62T, Diamond Core Drilling for Site Investigation, should be called for in performing core borings.

The cost of making core borings will depend upon the location of the work, quantity, and the difficulty encountered in getting to the holes.

The drilling costs per lin. ft. should be estimated at from $5.00 to $10.00 per foot of drilling with the lower costs on jobs of larger size. To the above prices must be added the on and off charges for the equipment and men, and testing charges.

Other Methods.—Other methods of making subsoil investigations, such as driving a rod into the soil, obtaining samples by simply driving an open end pipe into the soil, well drilling employing the formation of a slurry, ordinary wash borings, etc., produce little or no accurate information on soil conditions and are not recommended by reputable foundation engineers.

Seismic resistivity, vane shear tests, cone penetration tests and nuclear methods are becoming more frequently used in subsurface

investigation work. The cost of such surveys would be difficult to estimate.

Engineering Interpretation.—To the above drilling charges costs should also be anticipated for professional engineering fees covering the services of qualified soil and foundation engineers who should be retained to interpret the subsoil information.

DRILLING WATER WELLS

The pollution of streams by various industrial wastes is driving many municipalities and industries to wells for their water supply.

Where glacial stratas are encountered, large quantities of water may be found in the sand and gravel. The quality of gravel water is always harder than sand rock water and usually of lower temperature.

When large quantities of water are desired it is customary to drill a test hole to determine if the strata is suitable for water to travel through. If it is, blank pipe is driven to the top of the water bearing strata and a screen is set in it. A turbine pump is the best type of pumping equipment.

The travel of water through a well screen has a tendency to precipitate the solids from the water and close the screen as well as close up the openings in the gravel. Some water closes the screens readily, while other screens remain open indefinitely. When screens do close they can sometimes be opened by treating them with acid.

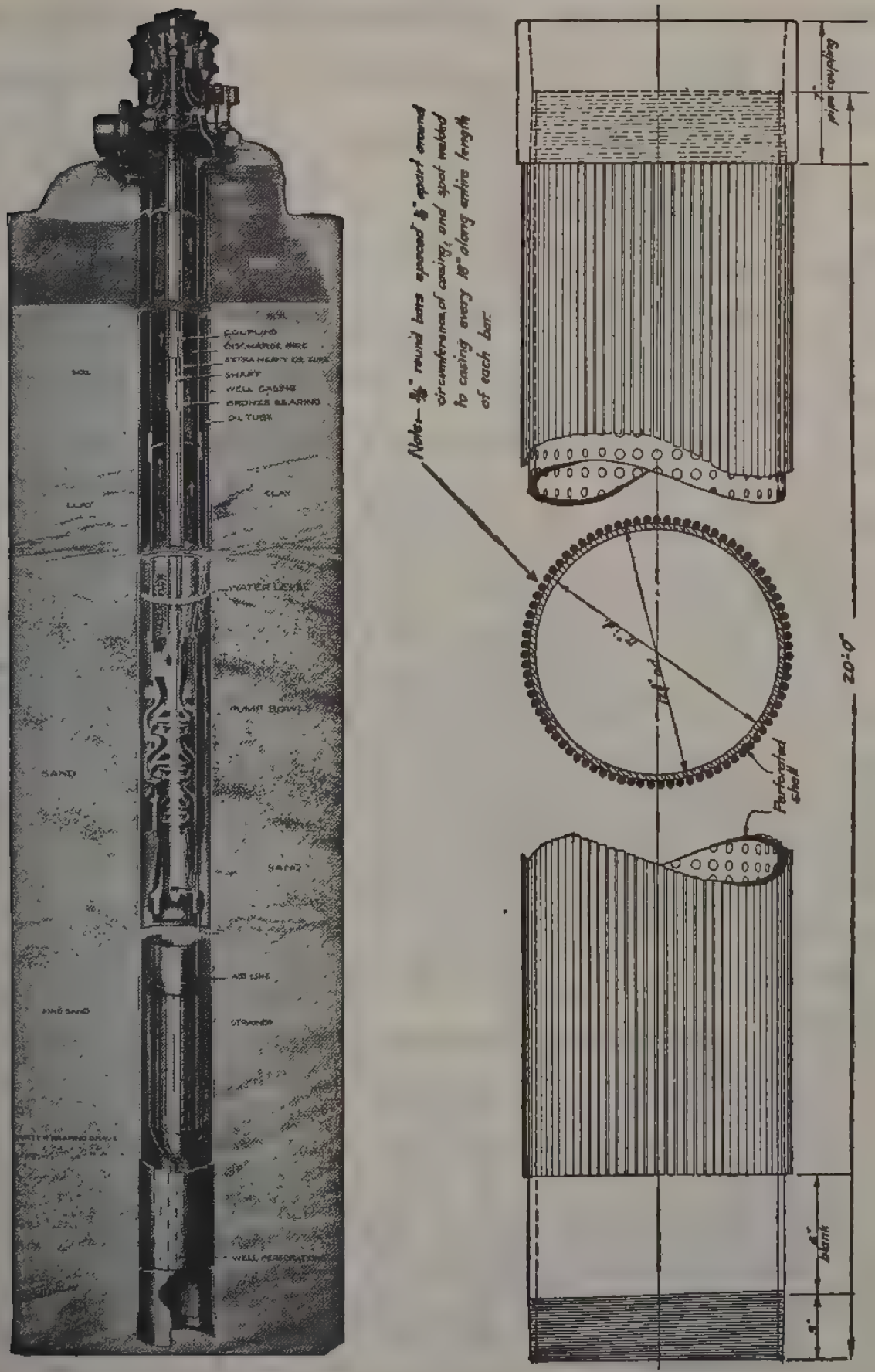
Rock wells are drilled by driving the pipe or casing to the surface of the rock and continuing with an open hole the inside diameter of the casing through the rock.

It is possible to increase the quantity of water from a rock well by shooting when the water rock is massive, close grained and not creviced. However, if the water bearing strata is loose, porous and creviced the shooting is not beneficial.

The most satisfactory type of pump for a rock well is an electric driven turbine pump.

Gravel wells cost, including pipe and screen, from $3.50 to $4.00 per inch in diameter, per lin. ft. of vertical depth, i.e., a 12" well in gravel would cost from $42.00 to $48.00 per lin. ft. of depth.

Rock wells cost about $1.25 per inch of diameter, plus cost of pipe, per lin. ft. of depth, as follows: a 6" well would cost $7.50 per lin. ft. of vertical depth, plus the cost of pipe. Of course in rock, pipe is not used but if there is 100' 0" of earth or gravel over the rock, it would be necessary to figure pipe for



Casings, Screens and Pumps Used in Modern Water Wells.

this portion, then when rock is struck, the pipe would no longer be necessary.

Turbine pumps cost from $1,500.00 to $6,000.00, depending upon capacity and head of water.

There is no appreciable difference in the lineal foot cost of water wells according to their depth. As a rule, the larger wells run from 100'-0" to 400'-0" in depth and a higher price per inch of diameter would apply to shallow wells, due to the cost of the screens.

It is suggested that quotations for drilling a specific well be asked for from local well drilling contractors who have knowledge of the area and know the approximate depth to the water bearing strata.

WOOD SHEET PILING AND BRACING

Wood sheet piling and bracing is usually estimated by the square foot, taking the number of sq. ft. of bank or trench walls to be braced or sheet piled, plus an additional amount for penetration at the bottom of the excavation, and an allowance for extension above the top, and estimating the cost of the work at a certain price per sq. ft. for labor and lumber required.

Sheet piling or bracing is required where the soil is not self-supporting or where the excavation adjoins a property line. In ordinary soil and excavation 7 or 8 feet deep may be self supporting and not require sheeting. There is usually considerable vibration adjacent to railroad or motor bus routes, etc., which may cause the banks to cave in. Unless there is ample space on all sides of the excavations, the banks should be sheet piled to avoid damage to streets, alleys or adjacent buildings.

Trenches or foundation piers 5'-0" to 8'-0" deep and 3'-0" or 4'-0" wide may require bracing or sheet piling but this is much simpler than is ordinarily required for basement excavations.

The cost of this work will vary with the kind of soil, depth of excavation, amount of bracing or sheet piling required and the method used in placing same.

In ordinary excavations where no water is encountered, 2" or 3" square edge planks may be used but if running sand or water is encountered, tongue and grooved planks should be used as it is easier to keep them in line and they are more water tight than square edge planks. It is customary to cut the bottom edge of each plank on a slight angle, so that in driving it is wedged against the preceding plank. The upper corners of the plank should also be cut off so that the effect of the driving will be concentrated along the vertical axis of the plank.

It requires 3 to 3½ ft. of lumber, b.m. to sheet pile one sq. ft. of trench bank 5′-0″ to 8′-0″ deep, but on large deep excavations it will require 6 to 8 ft. of lumber, b.m. per sq. ft. of wall.

Sheet piling is usually driven with a large sledge or wooden mallet, but the latter is preferable, as it is not so likely to split the planks while they are being driven.

Where compressed air is available, considerable time and money can be saved by driving the sheet piling with a pneumatic hammer designed especially for this purpose.

On very large jobs an ordinary pile driver is used for driving the sheet piling but this is done only on jobs of sufficient size to warrant the cost of installing a pile driver and crew.

Bracing and Sheet Piling Trenches and Piers.—When excavating trenches and piers 5′-0″ to 8′-0″ deep, it is not always necessary to sheathe the banks solid but two or three lines of braces placed along the sides of the trench, as illustrated, will often be sufficient.

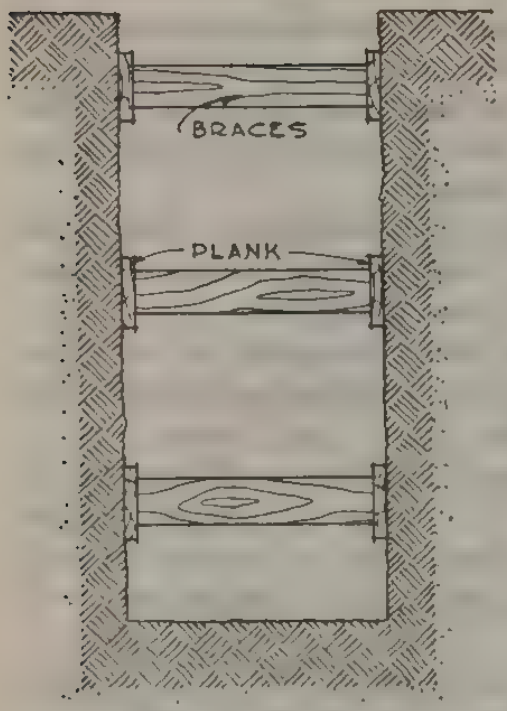
Where necessary to sheathe the banks solid, it will require about 3 to 3½ ft. of lumber, b.m. per sq. ft. of trench bank.

An example of the method used in determining the quantity of lumber required for sheet piling a trench similar to the one illustrated, is as follows: Compute the quantity of lumber necessary to sheet pile a trench 50′-0″ long and 7′-0″ deep, sheathed on both sides. To the depth of 7′-0″ must be added an amount for penetration. If 1′-0″ will be sufficient, then 8′-0″ lumber may be figured. If, however, 2′-0″ penetration is required, then 10′-0″ lumber must be figured leaving 1′-0″ to extend above grade. Assuming 2′-0″ penetration is required and 10′-0″ lumber must be used, this is equivalent to 100 lin ft. of sheathing 10′-0″ high, or 1,000 sq. ft., and the following lumber will be required:

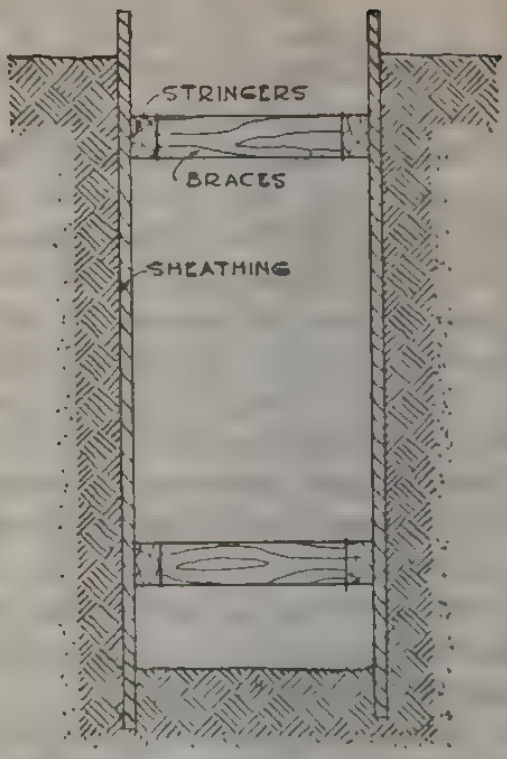
	Ft. B.M.
150 pcs. 2″x8″-10′-0″ sheathing	2,000
12 pcs. 4″x6″-16′-0″ stringers or "wales"	384
26 pcs. 4″x6″-2′-0″ braces spaced about 4′-0″ apart	104
Total lumber required	2,488
Feet of lumber, b.m. per sq. ft. sheathing, (divide by 1,000)	2.49
Feet of lumber, b.m. per sq. ft. trench bank, (divide by 700)	3.54

This is based on using 2″ plank for sheathing, 2 rows of 4″x6″ stringers or "wales" placed near the top and bottom as illustrated, and 4″x6″ or 6″x6″ braces. Trenches over 10′-0″ deep will require an additional line of stringers for each additional 4′-0″ to 5′-0″ depth.

Most contractors, who do a volume of this work, use trench



Method of Bracing Trench Excavation



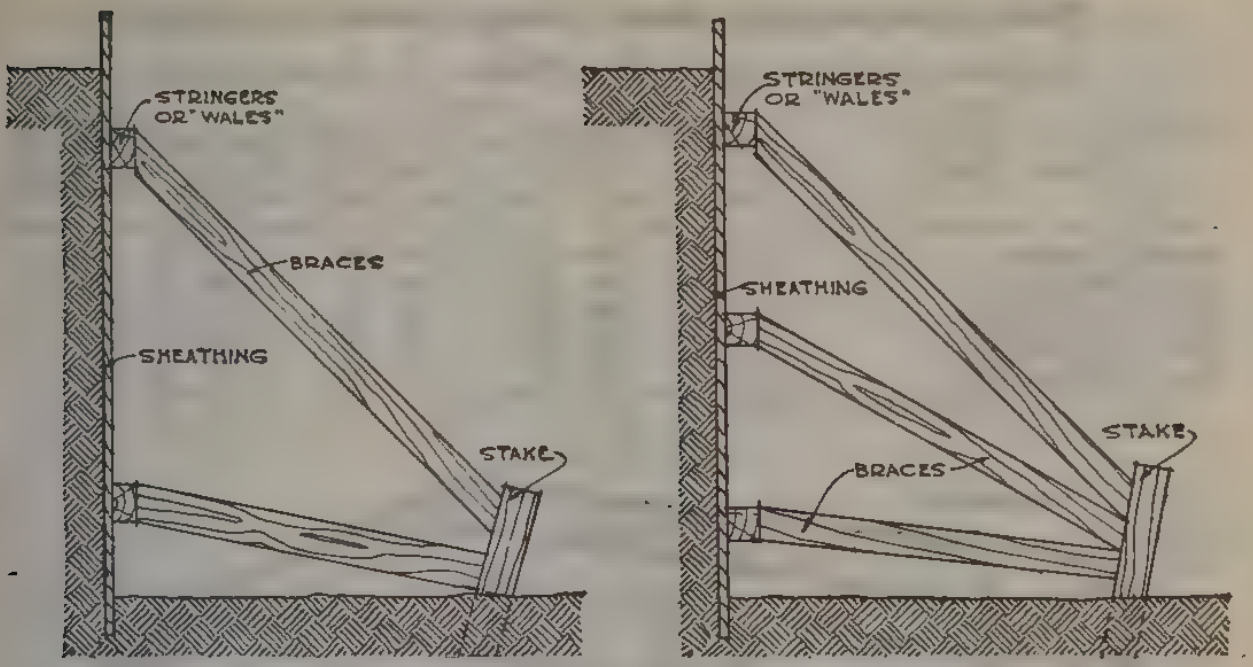
Method of Sheet Piling Trench Excavation

jacks in lieu of the 4"x6" or 6"x6" braces. Inasmuch as these jacks cost from $125.00 to $150.00 each, it would not be economical for the contractor who does only an occasional job of this sort to invest in this equipment as the savings in both material and labor are so slight they are practically negligible.

Sheet Piling for Basements and Deep Foundations.—On general basement excavation or large piers 8'-0" to 12'-0" deep, where it is necessary to brace any one or all of the outside banks, the following is an example of the lumber required for a bank 50'-0" long, 8'-0" deep, and containing 400 sq. ft. of bank to be sheathed:

	Ft. B.M.
80 pcs. 2"x8"-10'-0" sheathing	1,067
6 pcs. 6"x8"-16'-0" (2 lines of stringers or "wales")	384
10 pcs. 8"x8"-12'-0" top braces spaced about 5'-0" apart	640
10 pcs. 8"x8"-6'-0" bottom braces spaced about 5'-0" apart	320
10 pcs. 8"x8"-6'-0" stakes spaced about 5'-0" apart	320
Total lumber required	2,731
Feet, b.m. per ft. sq. ft. of sheet piling, (divide by 500)	5.46
Feet, b.m. per sq. ft. of bank, (divide by 400)	6.83

On deep excavations and piers 14'-0" to 20'-0" below grade 3" plank should be used for sheathing and either 6"x8" or 8"x8" lumber for stringers or "wales" and 8"x8" or 10"x10" timbers for bracing. Lines of stringers or "wales" should be



Methods of Bracing Basements or Deep Excavations.

spaced 4′-0″ to 5′-0″ apart, depending upon the earth pressure.

An example of the lumber required to sheet pile and brace a bank 50′-0″ long and 16′-0″ deep, containing 800 sq. ft. of bank, is as follows:

	Ft. B.M.
80 pcs. 3″x8″-18′-0″ sheathing	2,880
9 pcs. 8″x8″-16′-0″ (3 lines of stringers or "wales")	768
10 pcs. 8″x8″-16′-0″ top braces spaced 5′-0″ apart	853
10 pcs. 8″x8″-12′-0″ Intermediate braces spaced 5′-0″ apart	640
10 pcs. 8″x8″-8′-0″ bottom braces spaced 5′-0″ apart	427
10 pcs. 8″x8″-6′-0″ stakes spaced 5′-0″ apart	320
Total lumber required	5,888
Ft. b.m. per sq. ft. of sheet piling, (divide by 900)	6.54
Ft. b.m. per sq. ft. of bank (divide by 800)	7.36

Cost of lumber should be computed according to number of times it can be used on the job.

Where labor hours are given, either carpenters or laborers may be used, as required.

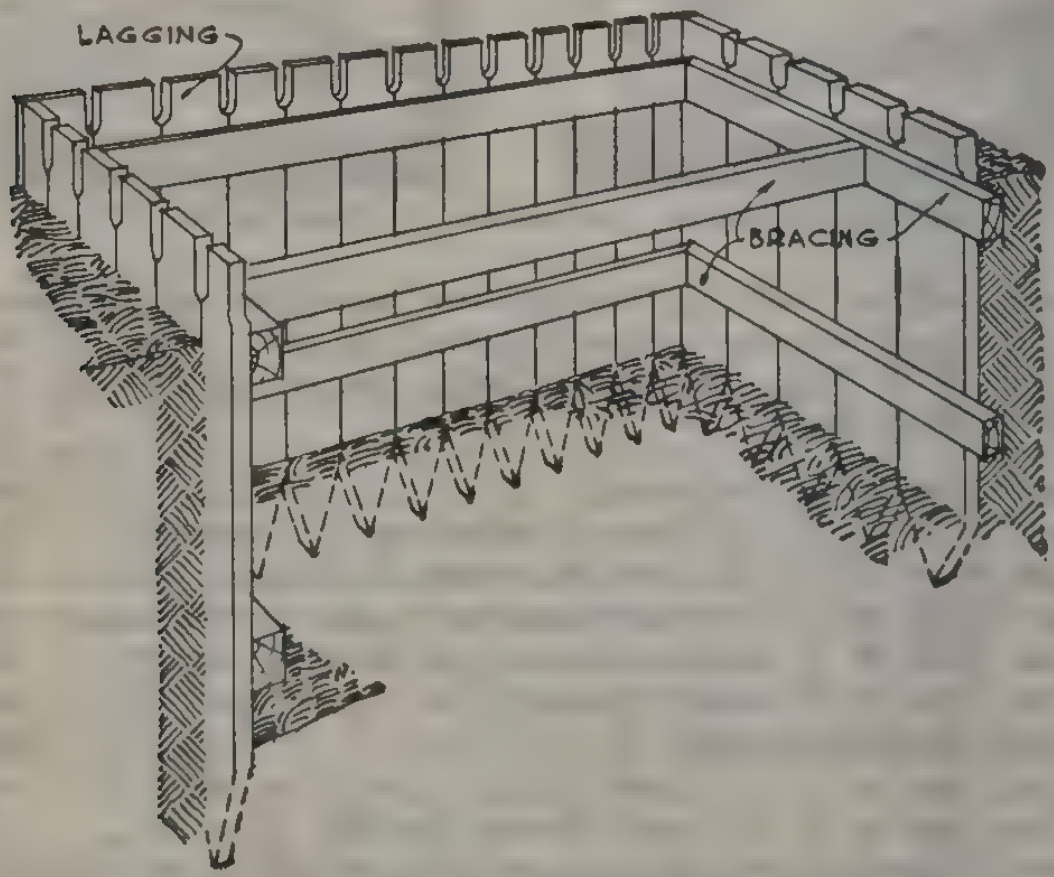
Lumber Required for Sheet Piling

Size of Timbers	Width Sq. Edge	100 Lin. Ft. Covers Sq. Ft.	Ft. B. M. per 100 Sq. Ft.	Width T & G	100 Lin. Ft. Covers Sq. T.	Ft. B. M. per 100 Sq. Ft.
2″ x 8″	7½″	62½	215	7¼″	60	220
3″ x 8″	7½″	62½	320	7¼″	60	330
2″ x 10″	9½″	79	210	9¼″	77	215
3″ x 10″	9½″	79	315	9¼″	77	320

Wood Bracing and Sheet Piling Banks By Hand

Quantities and Costs are given per 100 sq. ft. of bank braced

Class of Work	Depth in Feet	Ft. B. M. Lbr. Req'd 100 Sq. Ft. Bank	No. Sq. Ft. Placed per 8-Hr. Day	Labor Hrs. Placing 100 Sq. Ft.	Labor Hrs. Removing 100 Sq. Ft.
Bracing Trenches	5- 8	100-150	150-200	4- 5	1 -1½
Trench Sheet Piling	5- 8	300 350	80- 90	9-10	2½-3
Trench Sheet Piling	10-15	325-375	65- 75	11-12	2½ -3
Basement Sheet Piling	8-12	675-725	40- 50	17 18	5 -5½
Basement Sheet Piling	14-20	750-800	35- 45	20 21	5½-6



Method of Sheet Piling and Bracing Piers and Pits.

Cost of Bracing 100 Sq. Ft. of Trench Bank With Plank Bracing

	Hours	Rate	Total	Rate	Total
125 ft. lumber, b.m.		$.....	$.....	$0.15	$18.75
Labor placing	4.50	.....	.....	5.00	22.50
Labor removing**	1.25	.....	.....	5.00	6.25
Cost per 100 sq. ft.	5.75	.....	$.....		$47.50
Cost per sq. ft.					0.48

**Omit labor removing bracing or piling if left in place.

Cost of Sheet Piling 100 Sq. Ft. of Trench Walls 5′-0″ to 8′-0″ Deep

	Hours	Rate	Total	Rate	Total
325 ft. lumber, b.m. ..		$.....	$.....	$0.15	$48.75*
Labor placing	9.50	.....	.....	5.00	47.50
Labor removing** ...	2.75	.....	.....	5.00	13.75
Cost per 100 sq. ft..	12.25		$.....		$110.00
Cost per sq. ft.			...		1.10

Cost of Sheet Piling 100 Sq. Ft. of Trench Walls 10′-0″ to 15′-0″ Deep

	Hours	Rate	Total	Rate	Total
350 ft. lumber, b.m. ..		$.....	$.....	$0.15	$52.50*
Labor placing	11.50	.....	.....	5.00	57.50
Labor removing**	2.75	.....	.....	5.00	13.75
Cost per 100 sq. ft.	14.25		$.....		$123.75
Cost per sq. ft.			.....		1.24

Cost of 100 Sq. Ft. of Sheet Piling for Basements or Foundations 8′-0″ to 12′-0″ Deep

	Hours	Rate	Total	Rate	Total
700 ft. lumber, b.m....		$.....	$.....	$0.15	$105.00*
Labor placing	17.50	.....	.....	5.00	87.50
Labor removing**...	5.25	.....	.....	5.00	26.25
Cost per 100 sq. ft..	22.75		$.....		$218.75
Cost per sq. ft.....			$.....		2.19

Cost of 100 Sq. Ft. of Sheet Piling for Basements or Foundations 14′-0″ to 20′-0″ Deep

	Hours	Rate	Total	Rate	Total
775 ft. lumber, b.m. ..		$.....	$.....	$0.15	$116.25*
Labor placing	20.50	.....	.....	5.00	102.50
Labor removing** ...	5.75	.....	.....	5.00	28.75
Cost per 100 sq. ft..	26.25		$.....		$247.50
Cost per sq. ft.....			.....		2.48

*Lumber costs will vary according to number of times used.
**Omit labor removing bracing or piling if left in place.

Driving Sheet Piling by Compressed Air.—Pneumatic pile drivers, similar to the one illustrated are very effective for driving sheet piling. They are essentially a heavy paving breaker equipped with a special fronthead which is adjustable

Driving Sheet Piling by Compressed Air

for driving 2" to 3" piling. These machines weigh about 125 lbs. and will drive wooden sheet piling in any ground which the piling will penetrate, such as sand, gravel or shale and any gradation between soils.

Its driving speed varies from 2'-0" per minute in hard clay or shale to 9'-0" per minute in sand or gravel.

Under average conditions, two men working together on one machine should drive 100 lin. ft. (60 to 79 sq. ft.) per hr. at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Jackhammerman	1	$.....	$.....	$5.25	$5.25
Helper	1	.....	.....	5.00	5.00
Compressor expense ...	1	.....	.....	4.80	4.80
Cost per 100 lin. ft...	2		$.....		$15.05

		Total	Total
Cost per lin. ft.		$.....	$1.51
Cost per sq. ft. 8" sq. ed. (÷62½)		.....	.241
Cost per sq. ft. 8" T&G (÷60)		.....	.251
Cost per sq. ft. 10" sq. ed. (÷79)		.....	.191
Cost per sq. ft. 10" T&G (÷77)		.....	.196

Add for compressor engineer if required.

Cost of Sheet Piling 100 Sq. Ft. of Trench Banks 5'-0" to 8'-0" Deep, Using Pneumatic Hammers

	Hours	Rate	Total	Rate	Total
325 ft. lumber, b.m. ..		$.....	$.....	$0.15	$ 48.75*
Jackhammerman	2.00	.....	.....	5.25	10.50
Labor	4.00	.....	.....	5.00	20.00
Labor removing	2.75	.....	.....	5.00	13.75
Compressor	2.0	.....	.....	4.80	9.60
Compressor Engineer	2.0	.....	.....	6.00	12.00**
Cost per 100 sq. ft..	10.75	.....	$.....		$114.60
Cost per sq. ft.....			.....		1.15

Cost of Sheet Piling 100 Sq. Ft. of Trench Banks 10'-0" to 15'-0" Deep, Using Pneumatic Hammers

	Hours	Rate	Total	Rate	Total
350 ft. lumber, b.m...		$.....	$.....	$0.15	$ 52.50*
Jackhammerman	2.00	.....	.....	5.25	10.50
Labor	4.50	.....	.....	5.00	22.50
Labor removing	2.75	.....	.....	5.00	13.75
Compressor	2.0	.....	.....	4.80	9.60
Compressor Engineer	2.0	.....	.....	6.00	12.00**
Cost per 100 sq. ft..	11.25		$.....		$120.85
Cost per sq. ft.....			.....		1.21

Cost of 100 Sq. Ft. of Sheet Piling for Basements or Foundations 8'-0" to 12'-0" Deep, Using Pneumatic Hammers

	Hours	Rate	Total	Rate	Total
700 ft. lumber, b.m...		$.....	$.....	$0.15	$105.00*
Jackhammerman	2.00	.....	.....	5.25	10.50
Labor	12.00	.....	.....	5.00	60.00
Labor removing	5.25	.....	.....	5.00	26.25
Compressor	2.0	.....	.....	4.80	9.60
Compressor Engineer	2.0	.....	.....	6.00	12.00**
Cost per 100 sq. ft...	23.25		$.....		$223.35
Cost per sq. ft.....			.....		2.23

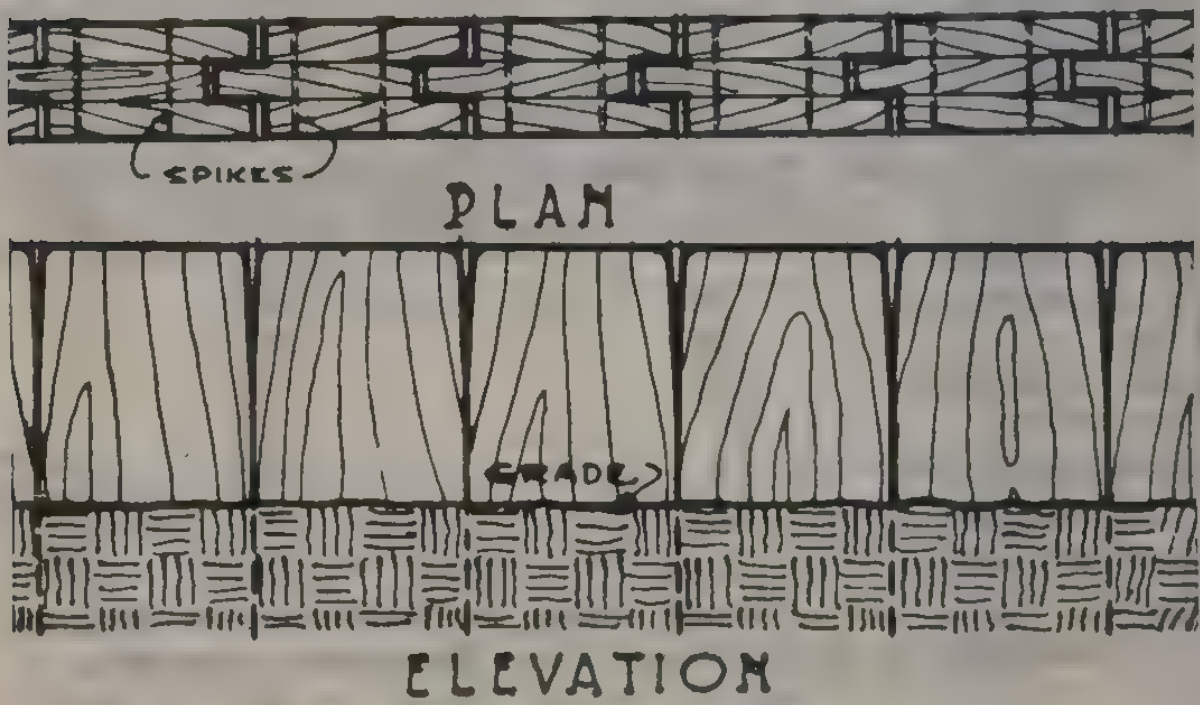
*Lumber cost will vary with number of times it may be used.
**Add only if required.

Cost of 100 Sq. Ft. of Sheet Piling for Basements or Foundations 14′-0″ to 20′-0″ Deep, Using Compressed Air Hammers

	Hours	Rate	Total	Rate	Total
775 ft. lumber, b.m...		$.....	$.....	$0.15	$116.25*
Jackhammerman	2.00	.....	.....	5.25	10.50
Labor	14.00	.....	.....	5.00	70.00
Labor removing	5.75	.....	.....	5.00	28.75
Compressor	2.0	.....	.....	4.80	9.60
Compressor Engineer	2.0	.....	.....	6.00	12.00**
Cost per 100 sq. ft.	23.75		$.....		$247.10
Cost per sq. ft.....			.....		2.47

*Lumber cost will vary with number of times it may be used.

**Add only if required.



Method of Building Up and Driving Wood Sheet Piling.

Driving Wood Sheet Piling With a Pile Driver.—When wood sheet piling is driven by a pile driver, built-up sections consisting of 3 pcs. of 2″x12″ or 3″ x12″ plank are spiked together, forming a tongue and groove, as illustrated above.

These sections are sharpened on one end and driven in the same manner as ordinary wood piles, and at about the same labor costs. Including both labor and material, this will average $2.60 to $3.10 per sq. ft.

STEEL SHEET PILING

Steel sheet piling is used for supporting the soil in large excavations, cofferdams, caissons, and deep piers or trenches where wood sheet piling is impractical. It is driven with a pile driver the same as wood or concrete piles.

There are a number of different types of steel sheet piling on the market but the following will furnish an idea of the sizes, weights, etc., commonly used.

Sizes and Weights of United States Steel Sheet Piling

Section Number	Width Inches	Web Thick. Inches	Wt. Lbs. per Lin. Ft.	Wt. Lbs. per Sq. Ft. Wall
MZ38	18″	⅜″	57.0	38.0
MZ32	21″	⅜″	56.0	32.0
MZ27	18″	⅜″	40.5	27.0
MP102	15″	½″	40.0	32.0
MP101	15″	⅜″	35.0	28.0
MP113	16″	½″	37.3	28.0
MP112	16″	⅜″	30.7	23.0
MP110	16″	31/64″	42.7	32.0
MP116	16″	⅜″	36.0	27.0
MP115	19⅝″	⅜″	36.0	22.0

Estimating the Quantity of Steel Sheet Piling.—When estimating the quantity of steel sheet piling required for any job, take the entire girth of the basement, cofferdam or piers to be sheet piled, which gives the number of lineal feet required. Example: suppose you have a basement 100′x0″x125′-0″ to be sheet piled. Adding the four sides of the excavation, 100+100+125+125=450 lin. ft. Using MZ-27 Carnegie Illinois sheet piling 18″ wide. 450′-0″÷1.50′=300, or it requires 300 pcs. to sheet pile the excavation. Using sheet piling 30′-0″ long, 300x30 =9,000 lin. ft. weighing 40.5 lbs. per lin. ft. equals 364,500 lbs.

A shorter method is as follows: 450 lin. ft. around excavation multiplied by 30′-0″ long, equals 13,500 sq. ft. of piling at 27 lbs. per sq. ft. equals 364,500 lbs.

Either method is satisfactory, except it is necessary to know the number of pieces to be driven to compute the labor costs accurately.

Labor Driving Steel Sheet Piling.—The labor cost handling and driving steel sheet piling will vary with the size of the job, length of piling, kind of soil, etc., together with conditions encountered on the job, as described under "Wood Piles."

Example: Find the cost of driving 300 pcs. of MZ-27 sheet piling 30′-0″ long.

	Total	Total
Trucking pile driver, yard to job	$.....	$ 500.00
Setting up pile driver, 3 days for crew	.....	1,098.00
300 pcs. MZ-27 piling, 364,500 lbs. at $0.12	.....	43,740.00
Driving piling (30 per day) 10 days @ $366.00	.....	3,660.00
Fuel, oil, misc. supplies, 10 days @ $30.00	.....	300.00
Dismantling pile driver at completion, 2 days	.....	732.00
Trucking pile driver, job to yard	.....	500.00
Interest, depreciation, etc., 16 days @ $180.00	.....	2,880.00
Workmen's Comp. Ins., Soc. Sec., Unemp. Taxes, 15%	.....	823.50
Overhead and profit, 25%	.....	13,558.38
Cost 300 pcs. sheet piling	$.....	$67,791.88
Cost per pc.	.....	225.97
Cost per sq. ft. (13,500 sq. ft.)	.....	5.02

Sq. ft. costs will vary with weight of piling used, size of job, etc.

WOOD PILES

When estimating the cost of wood piles the item of overhead expense must be considered before the actual cost of driving the piles can be computed. This includes cost of moving the equipment to the job, setting it up ready to operate and dismantling and removing at completion.

This item will remain practically the same regardless of the size of the job, as the equipment charge will be as much on a job having 100 piles as on a job containing 1,000 piles.

The actual cost of driving the piles will vary with soil conditions, length of piles and the amount of moving necessary.

Setting up and Removing Equipment.—The cost of moving the pile driving equipment to the job must be taken into consideration, and then after it arrives at the job, there is the task of setting up the pile driver and getting ready to operate.

After the pile driver has been delivered at the job it should take about 3 days time for the crew to set it up ready to drive and this should cost as follows:

Setting up Equipment	Hours	Rate	Total	Rate	Total
Foreman	24	$.....	$.....	$6.30	$ 151.20
Engineer on pile driver	24	.....	.....	6.20	148.80
Oiler	24	.....	.....	5.10	122.40
2 pile driver men	48	.....	.....	6.00	288.00
4 men, general labor	96	.....	.....	5.00	480.00
Total labor cost	216		$.....		$1190.40

The above item will remain practically the same whether there are 100 or 1,000 piles to be driven.

After the job has been completed, the pile driver must be dismantled and removed from the job and the dismantling should cost as follows:

Dismantling Equipment	Hours	Rate	Total	Rate	Total
Foreman	16	$.....	$.....	$6.30	$100.80
Engineer on pile driver	16	.....	.....	6.20	99.20
Oiler	16	.....	.....	5.10	81.60
2 pile driver men	32	.....	.....	6.00	192.00
4 men, general labor	64	.....	.....	5.00	320.00
Total Labor Cost	144		$.....		$793.60

Driving Wood Piles.—After the pile driver is set up and ready to operate, the labor cost of driving the piles will vary with the length of the piles and job conditions.

The following table gives the approximate number of piles of various lengths that should be driven per hour and per day:

Length of Piles	1 Hour	8 Hours	9 Hours	10 Hours
24 feet	4.5	36	40	45
26 feet	4.2	34	38	42
28 feet	4.0	32	36	40
30 feet	3.7	29	33	37
32 feet	3.5	28	31	35
34 feet	3.3	26	30	33
36 feet	3.1	25	28	31
38 feet	3.0	24	27	30
40 feet	2.8	22	25	28
45 feet	2.5	20	22	25
50 feet	2.3	18	21	23
55 feet	2.1	17	19	21
60 feet	2.0	16	18	20

The labor operating the pile driver per 8 hr. day should cost as follows:

	Hours	Rate	Total	Rate	Total
Foreman	8	$.....	$.....	$6.30	$ 50.40
Engineer on pile driver	8	.....	.....	6.20	49.60
Oiler	8	.....	.....	5.10	40.80
2 pile driver men	16	.....	.....	6.00	96.00
4 men, general labor	32	.....	.....	5.00	160.00
Labor cost per day	72		$.....		$396.80

The above does not include time laying out the work or spotting piles, pumping, shoring, excavating or cutting off

wood piles after they are driven, but includes only the actual time driving the piles. Neither does it include the cost of fuel, oil, and other supplies for the pile driver, which should be added.

Cutting off Wood Piles.—After the wood piles have been driven, the tops projecting above the ground will have to be cut off to receive the foundation which is to be placed upon them.

This cost will vary according to the size of the quarters in which the men are obliged to work, but on the average job it should require ½ to ¾-hrs. to cut off each wood pile 12″ or 14″ in diameter, at the following labor cost per pile:

	Hours	Rate	Total	Rate	Total
Labor	0.63	$.....	$.....	$5.00	$3.15

To the above costs, add time removing stumps or sawed-off ends of the piles from the premises.

Computing the Cost of Wood Piles.—As described above, the cost of driving wood piles will vary with the number of piles, length, kind of soil, and other job conditions.

Driving Wood Piles for an Apartment Building on the Lake Front in Chicago

An example of an estimate on driving 680 wood piles 40'-0" long is as follows:

	Local Rate	Total	Total
Trucking pile driver to job	$.....	$.....	$ 440.00
Setting up pile driver, 3 days for crew.	.....	.....	1,190.40
680 wood piles, 40'-0" long @ $60.00..	.....	.....	40,800.00
Driving piles (22 per 8-hr. day) 31 days @ $396.80	.....	.....	12,300.80
Fuel, oil, misc. supplies, etc. 31 days @ $24.00	.....	.....	744.00
Dismantling pile driver at completion, 2 days	.....	.....	793.60
Trucking pile driver, job to yard	.....	.....	440.00
Interest, depreciation, etc., 36 days @ $150.00	.....	.....	5,400.00
Workmen's Comp. Ins., Soc. Sec., Unemp. Taxes, 15%	.....	.....	2,142.72
Overhead expense and profit, 25%	.....	.....	16,062.88
Cost 680 piles		$.....	80,314.40
Cost per pile		.....	118.11
Cost per lin. ft.		.....	2.96

Add cost of cutting off piles after driving.

When preparing an estimate on wood piles of any length, always compute the overhead expense, depreciation charges, fuel, oil, etc., as given above. Then determine the number of piles of each length that can be driven per day to arrive at the actual time required by the pile driver and crew.

Average Cost of Wood Piles.—Based on the experience of one of the largest concerns driving wood piles, an average price on fair size jobs is $2.30 to $2.60 per lin. ft., not including overhead and profit.

A breakdown of the above average costs for various pile lengths, based on a job containing approximately 1,000 untreated piles, is as follows:

	Length of Pile in Feet				
	20	30	40	50	60
Pile material cost, per lin. ft.	$1.45	$1.56	$1.67	$1.90	$2.05
Labor driving, per lin. ft.	.67	.62	.59	.55	.52
Equipment costs, including fuel, oil, etc., per lin. ft.	.28	.26	.25	.24	.23
Moving equipment on and off job, Prorated per lin ft.	.22	.19	.18	.17	.15
Total cost per lin. ft.	$2.62	$2.63	$2.69	$2.86	$2.95

Treated piles will cost about 18 cts. additional per ft. of length.

Driving Wood Piles on a Large Chicago Job

CONCRETE PILES

Due to the wide variations and conditions under which concrete piles are installed and used, it is difficult to give dependable cost figures without possessing the details of each installation. The different types of piles also vary considerably in cost. When estimating work containing concrete piles, it is always advisable to consult contractors specializing in this class of work. Most of them maintain offices in the principal cities and are usually willing to investigate and quote on any anticipated work. Figures can thus be obtained with more accuracy than can be given in a general way.

There are two principal types of concrete pile: cast-in-place and precast. The cast-in-place pile is formed in the ground in the position in which it is to be used in the foundation. The precast pile is cast above ground and, after it has been properly cured, it is driven or jetted just like a wood pile.

In ordinary building foundation work the cast-in-place pile is more commonly used than the precast pile. The principal reasons for this are the following. The cast-in-place pile foundation can be installed more rapidly because there is no delay while test piles are being driven to predetermine pile lengths and there is no delay waiting for piles to cure sufficiently to withstand handling and driving stresses. Of particular importance in crowded locations is the fact that a cast-in-place pile job does not require a large open space for a pile-casting yard.

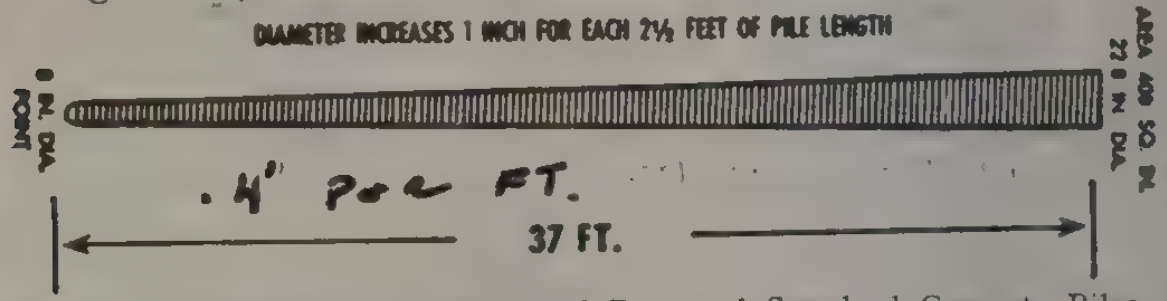
In marine installations either in salt or in fresh water, the precast pile is used almost exclusively. This is due to the difficulty involved in placing cast-in-place piles in open water. For docks and bulkheads, the cast-in-place pile is sometimes used in the anchorage system. On trestle type structures such as highway viaducts, the precast pile is more commonly used. A portion of the pile often extends above the ground and serves as a column for the superstructure. Precast concrete piles are always reinforced internally so they can resist stresses produced by handling and driving. Cast-in-place piles are rarely reinforced since lateral support of even the poorest of soils is sufficient to overcome any bending moments induced in the pile by column action.

Raymond* Concrete Piles—There are five general types of Raymond concrete piles described in the following pages, each designed for a specific purpose.

The Raymond Standard Concrete Pile is a tapered pile which is cast in the ground in a thin steel shell closed at the bottom with a steel boot. The shell is placed on the outside of a steel mandrel or pile core and the shell and core are driven into the

*Raymond Concrete Pile Division, Raymond International Inc.

ground. When sufficient driving resistance has been developed, driving is stopped and the core is withdrawn from the shell. The driven shell is inspected to determine that it is in good condition and it is then filled with concrete. The shell not only retains the soil pressure generated by driving, but it also protects the fresh concrete from being mixed with the surrounding soil or from being distorted by soil pressures set up by the driving of adjacent piles.



Length, Top and Point Diameters of Raymond Standard Concrete Piles.

The shells are made of sheet steel in 4'-0" and 8'-0" lengths and are reinforced with a spiral wire inside the shell on a 3 inch pitch.

The point diameter of the Raymond Standard pile is 8 inches and the diameter increases at the rate of 0.4 inches for each foot of pile length.

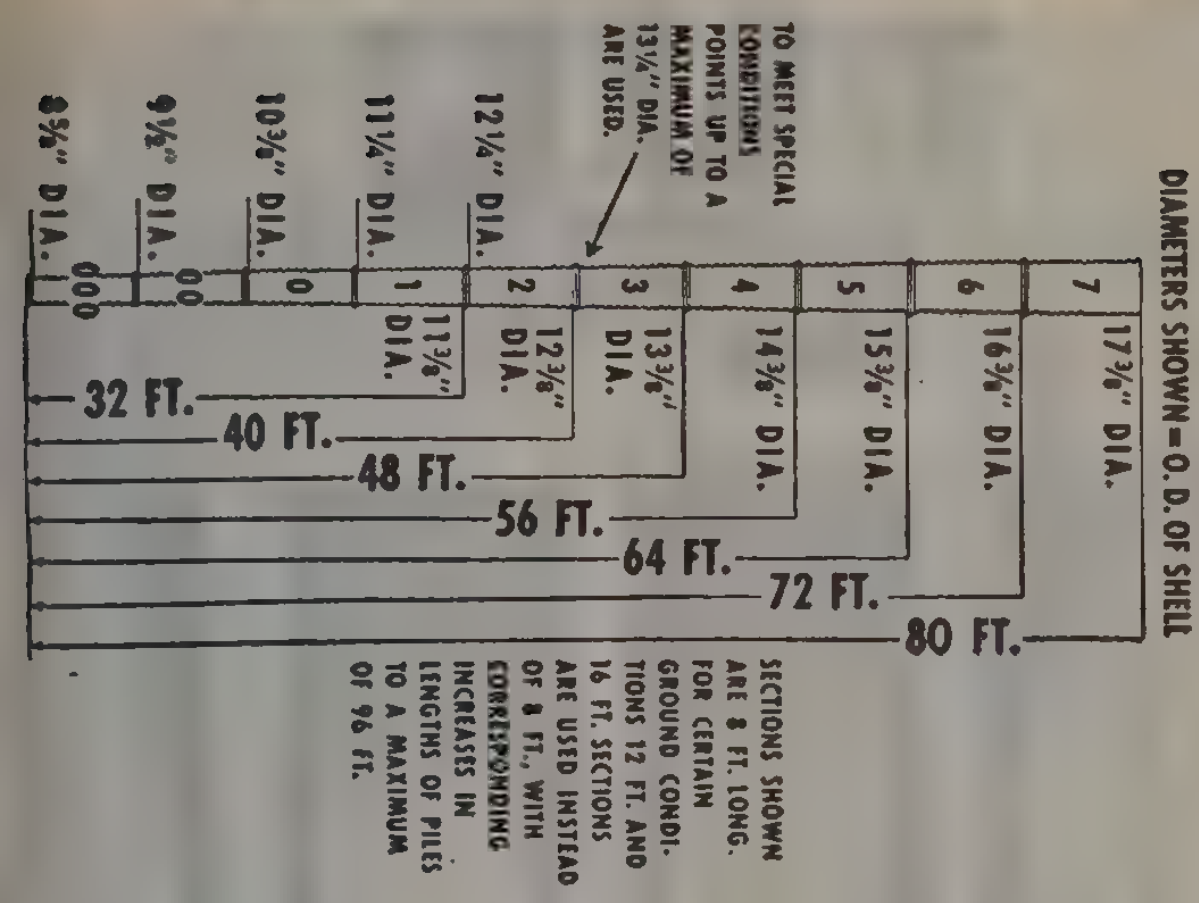
Dimensions and lengths of Raymond Standard concrete piles are as follows:

Length of Pile	Diameter at Top	Diameter at Point	Top Area Sq. In.
15'-0"	14"	8"	154
20'-0"	16"	8"	201
25'-0"	18"	8"	254
30'-0"	20"	8"	314
37'-0"	22.8"	8"	408

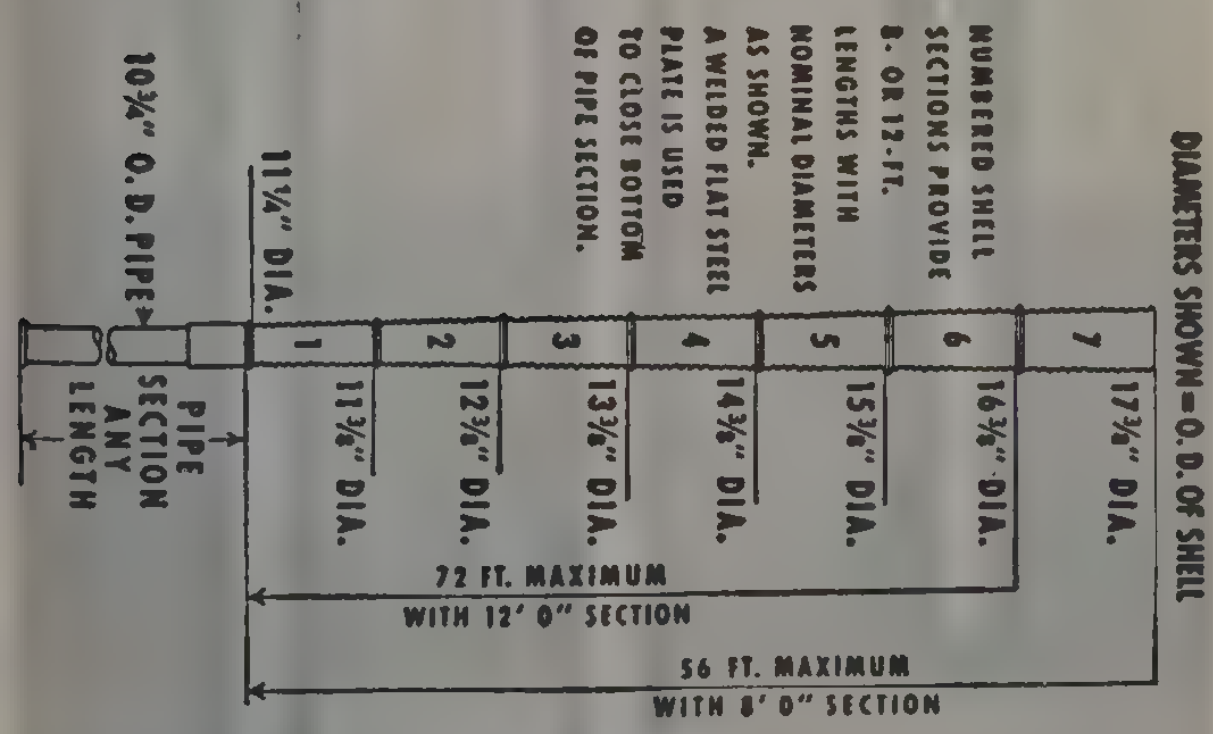
For practical reasons the length of the Raymond Standard concrete pile is limited to about 37'-0" and the Raymond step taper pile was developed to provide an all concrete pile that could be driven in considerably greater lengths, as piles of this type have been driven in lengths of more than 108 feet.

The shells are placed on a driving core and the core and the shells are then driven into the ground. The core is removed and the shell is filled with concrete. The shells are made of sheet steel and spirally corrugated. At the lower end the shell is closed with a flat steel plate.

The minimum point diameter of the Step Taper pile is 8 inches and the diameter of the pile increases in steps at the rate of 1 inch for each 4, 8, 12 or 16 feet of pile length depending upon the soil conditions encountered.



Lengths, Top and Point Diameter of Raymond Step Taper Concrete Piles



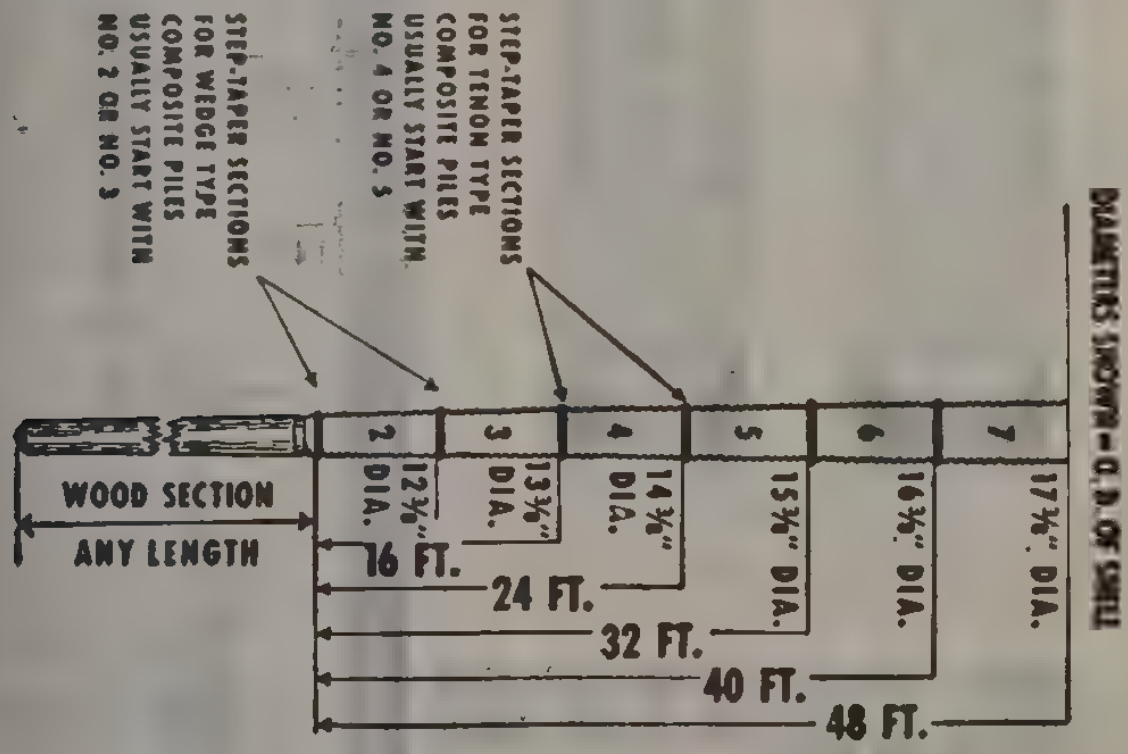
Lengths, Top and Point Diameters of Raymond Pipe-Step Taper Concrete Piles

Raymond Step Taper Concrete Piles

The Raymond Pipe-Step Taper pile is a combination of a steel pipe pile and a Raymond Step Taper pile. It was developed for the purpose of providing a cast-in-place concrete pile of great length. Piles of this type have been placed in lengths up to nearly 200 feet.

The pipe section is usually made of 10.75 O.D. pipe and the lowest shell section has a diameter of 11¼ inches. The diameter of the shell portion of the pile increases by steps at the rate of 1 inch for each 8 feet of pile length.

The Raymond Composite Wood and Concrete pile was developed for the purpose of providing a pile that could be driven in



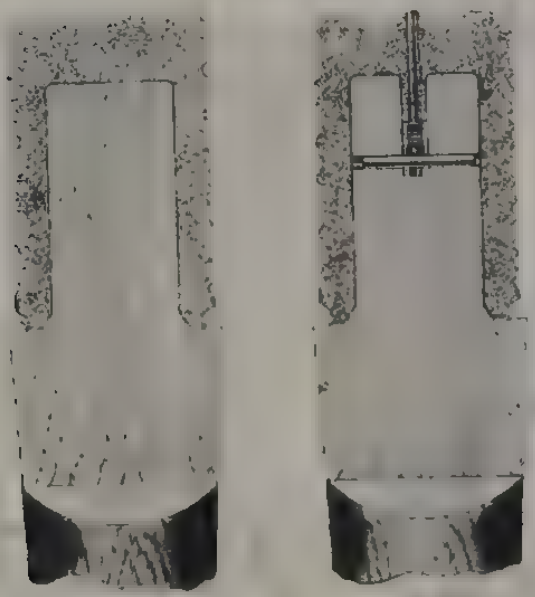
Lengths, Top and Point Diameters of Raymond Composite Wood and Concrete Piles

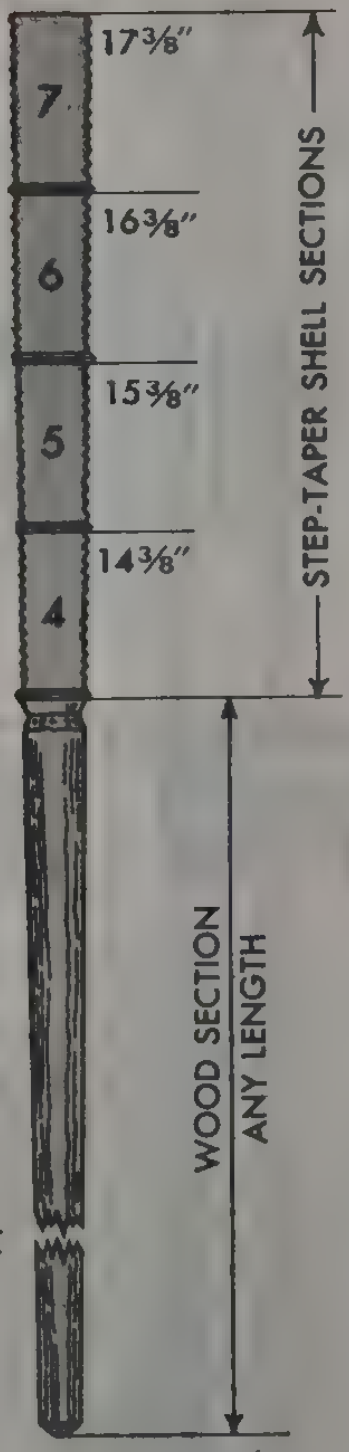
great lengths for prices less than the price of all concrete piles of the same length. The composite pile consists of a wooden lower section and a cast-in-place concrete upper section, which is a Raymond Step Taper pile.

The wood pile is driven first, after which it is followed down by the concrete section until the joint between the two sections is below the natural ground water table. The driving core is used as a follower and after the pile has reached satisfactory resistance, the core is removed from the shell which is then filled with concrete.

The illustration shows three types of joints that are commonly used to fasten the wood and the concrete sections together. In

diameters shown = O.D. of shell





Above Left: is a tenon-type joint with a sealing ring at the lower end of the shell.

Above Right: is a tenon-type joint with a rod, pin and socket.

Composite Wood and Concrete Pile and Methods of Jointing

the joint at the left, the wood pile has been provided with a tenon about 9 inches in diameter and 18 inches long. The spirally corrugated shell is provided with a sealing ring at its lower end. This ring is made of heavy sheet metal and is forced down over the tenon by the weight of the pile core so that it bites into the wood of the tenon and forms a seal to keep out mud and water.

In the pile at the center, the same tenon and sealing ring are used, but this joint includes a cross pin and a steel socket into which a reinforcing rod with a threaded end is inserted just before the concrete is poured. The purpose of the rod, pin and socket is to anchor the two sections of pile together so as to provide tensile resistance to any forces that might tend to separate the piles in tension.

The joint at the right is called a wedge ring joint. The wood pile is not provided with a tenon but the lower end of the pile shell is provided with a sheet metal projection which is forced into the top of the wooden pile. A tapered wedge-shaped ring of somewhat smaller diameter than the shell is then forced into the wood pile so as to expand the wood and produce a tight seal between the lower end of the shell and the wooden pile.

Wood sections of any length may be used. The concrete section is a cast-in-place step taper pile. When the wedge ring type of joint is used, the diameter of the bottom shell is either 12¼ inches or 13¼ inches. When tenon type joints are used, the bottom section of the step taper pile is either 14¼ inches or 15¼ inches in diameter. For all types of piles, the diameter of the step taper section increases at the rate of 1 inch for each 8 feet of pile length.

Steel Pipe Piles.—Another kind of cast-in-place pile with a permanent shell is the steel pipe pile, both open and closed end.

The closed end pipe pile is simply a piece of steel pipe, closed at the bottom with a heavy boot, then driven into the ground and filled with concrete. The uses and allowable loads for such piles are about the same as other types of cast-in-place piles with driven shells. On some jobs the pipe shell is driven all in one piece, but very often it is driven in sections which are welded together or fitted together with internal sleeves as the driving progresses.

Open end steel pipe piles are usually driven to bearing on rock. Since the pipe is open at the bottom during driving, the interior fills with soil which must be removed before concreting. Cleaning is usually done with air and water jets, after which the pipe is re-driven to insure proper seating in the rock, re-

*Raymond Concrete Pile Division, Raymond International Inc.

maining water is pumped out and the pipe pile is filled with concrete.

Open end pipe piles installed in this manner are usually allowed to carry relatively high working loads. They have been installed up to 24 inches in diameter and in lengths up to 200 feet.

Precast Concrete Piles.—Precast concrete piles are commonly used in marine structures, such as docks, piers, etc., where they are driven in open water.

Ordinarily they are designed for the particular job and made in a casting yard at or near the job site. The use of precast concrete piles usually delays the starting of actual pile driving because of the time involved in the casting and curing of this type of pile.

Precast concrete piles have the same advantages as other concrete piles over wood and steel piles. They are always reinforced internally to resist stresses produced by handling and driving.

Precast concrete piles have been driven in lengths up to 120 feet.

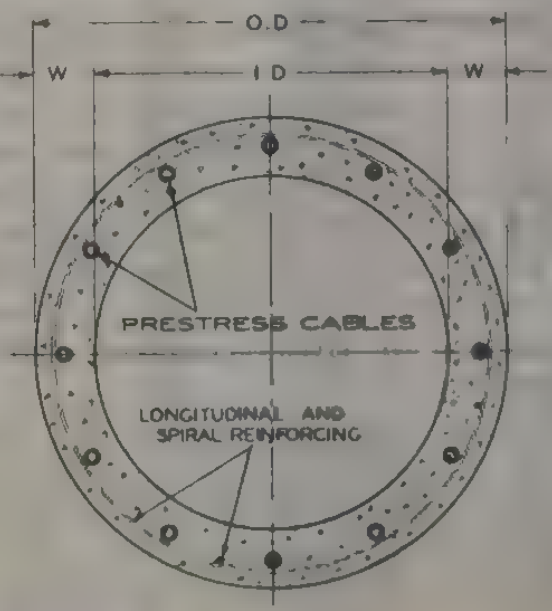
Prestressed precast concrete piles may be more economical than conventionally reinforced precast piles since less steel is necessary to adequately resist the handling and driving stresses.

Cylinder Piles.—Hollow centrifugally spun, longitudinally prestressed precast concrete piles are capable of carrying extremely high compression loads and resisting large lateral forces. Concrete strengths in excess of 7000 psi are attained by the spinning process.

These piles are generally furnished in diameters of 36 and 54 inches, with 4 to 5 inch walls. Sections are cast in 16 ft. length

STANDARD SIZES

OD	ID	W	NUMBER OF PRESTRESSING CABLES
36"	28"	4" and 4½"	8-10-12-14 or 16
54"	46"	4" and 5"	8-10-12-14 or 16



Raymond Prestressed Cylinder Piles

which are laid end to end to make up the required pile lengths and longitudinally post-tensioned.

Highway overpasses, oil drilling platforms, breakwaters, etc. are some conventional uses for Cylinder Piles.

Steel H-Beam Piles.—A comparatively recent development in pile foundation work is the use of rolled structural steel shapes as bearing piles. The shape commonly used for this purpose is the H-beam. This type of pile has proved especially useful for trestle structures in which the pile extends above the ground and serves not only as a pile but also as a column.

Because of their small cross-sectional area, piles of this type can often be driven through dense soils to point bearing where it would be difficult to drive a pile of solid cross-section, such as a wood cast-in-place or precast concrete pile. This ability to penetrate dense soils easily works to a disadvantage in other soil conditions. Where piles are used to support loads by friction or where they are used primarily for compaction, a considerably longer H-beam is required to carry the same load that can be supported by a pile of less length but greater cross-sectional area.

The upper ends of H-beam piles may be encased in concrete to prevent corrosion

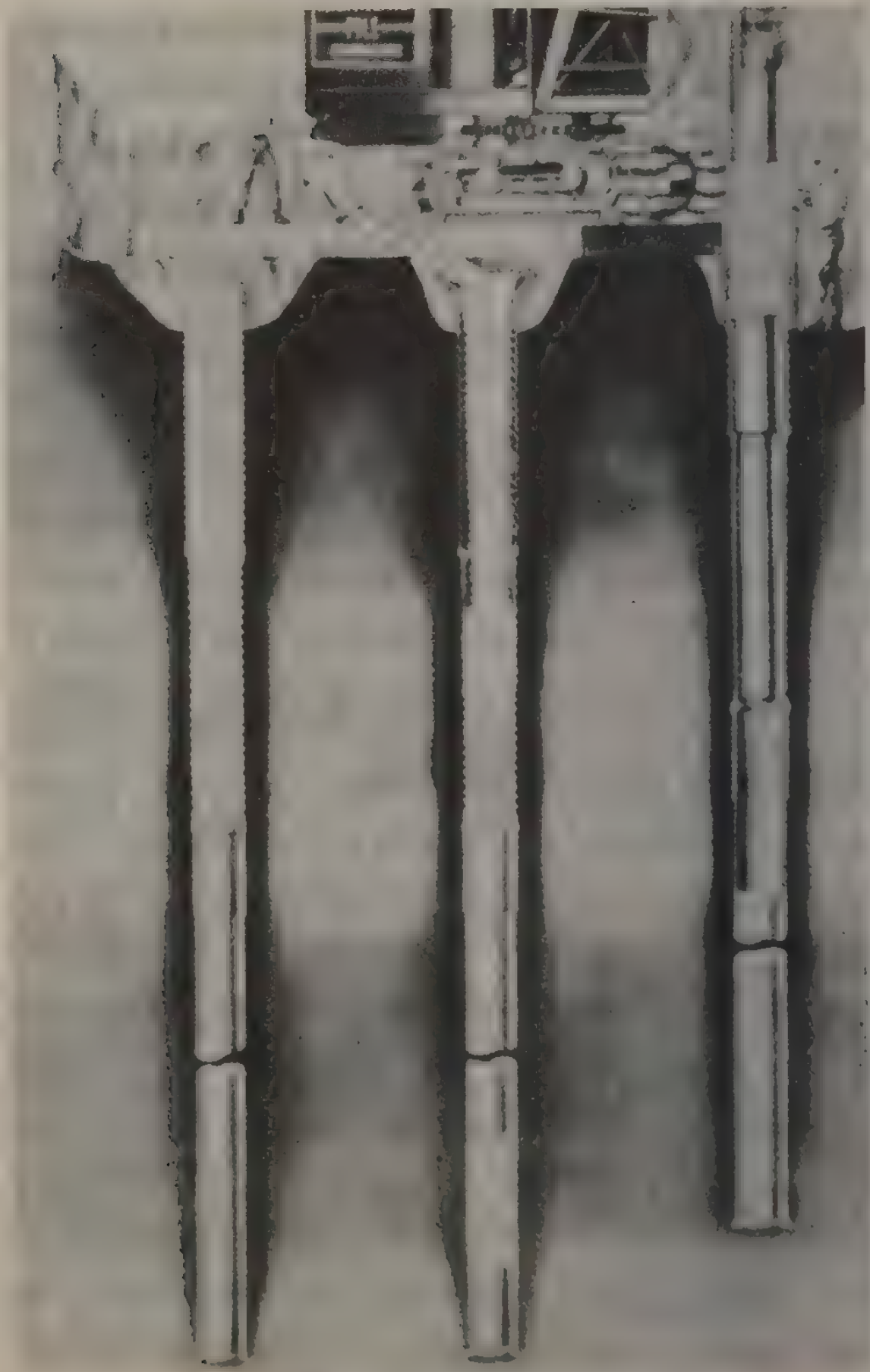
Steel H-beam piles, weighing 200 pounds per lin. ft., have been driven in lengths up to 130 feet and lighter sections to even greater lengths.

Estimating the Cost of Concrete Piles.—The cost of concrete piles will vary greatly, depending upon the number of piles in the job and the length of same as it is the total footage of piles in the job rather than the number of piles that controls the price. For example, the price per foot for 100 piles 35 feet long would be much greater than the price per foot for 1,000 piles 25 feet long.

Regardless of the size of the job there is a fixed charge for moving equipment on and off the job that will amount to $4,000.00 to $5,000.00, provided the equipment is located in the immediate vicinity of the contemplated work.

If it is necessary to ship plant and equipment from one city to another, it will be necessary to add additional freight and trucking amounting to $500.00 to $1,000.00, making a total fixed charge of $4,500.00 to $6,000.00, before figuring the cost of the piles.

Labor Setting Up and Removing Pile Driver.—Before the actual cost of driving the concrete piles can be considered, an allowance must be made for setting up the pile driver, dismantling and removing same at completion, etc.



Raymond Pipe-Step Taper Piles

After the pile driver has been delivered at the job site it should take about 4 days for the crew to set it up ready for driving, as follows:

	Hours	Rate	Total	Rate	Total
Foreman	32	$.....	$.....	$6.30	$ 201.60
Engineer	32	.....	.....	6.20	198.40
Oiler	36	.....	.....	5.10	183.60
Linesman	32	.....	.....	6.00	192.00
Pile driver men	128	.....	.....	6.00	768.00
					$1543.60
Insurance, Soc. Sec., Unemp. Comp.		.....	.....		231.54
Total setting-up cost	260		$.....		$1775.14

At the completion of the job, the pile driver must be dismantled and removed, which will require about 3 days time for the same crew as given above. In other words, figure about seventy-five (75%) percent as much for dismantling the pile driver as for setting it up ready for driving.

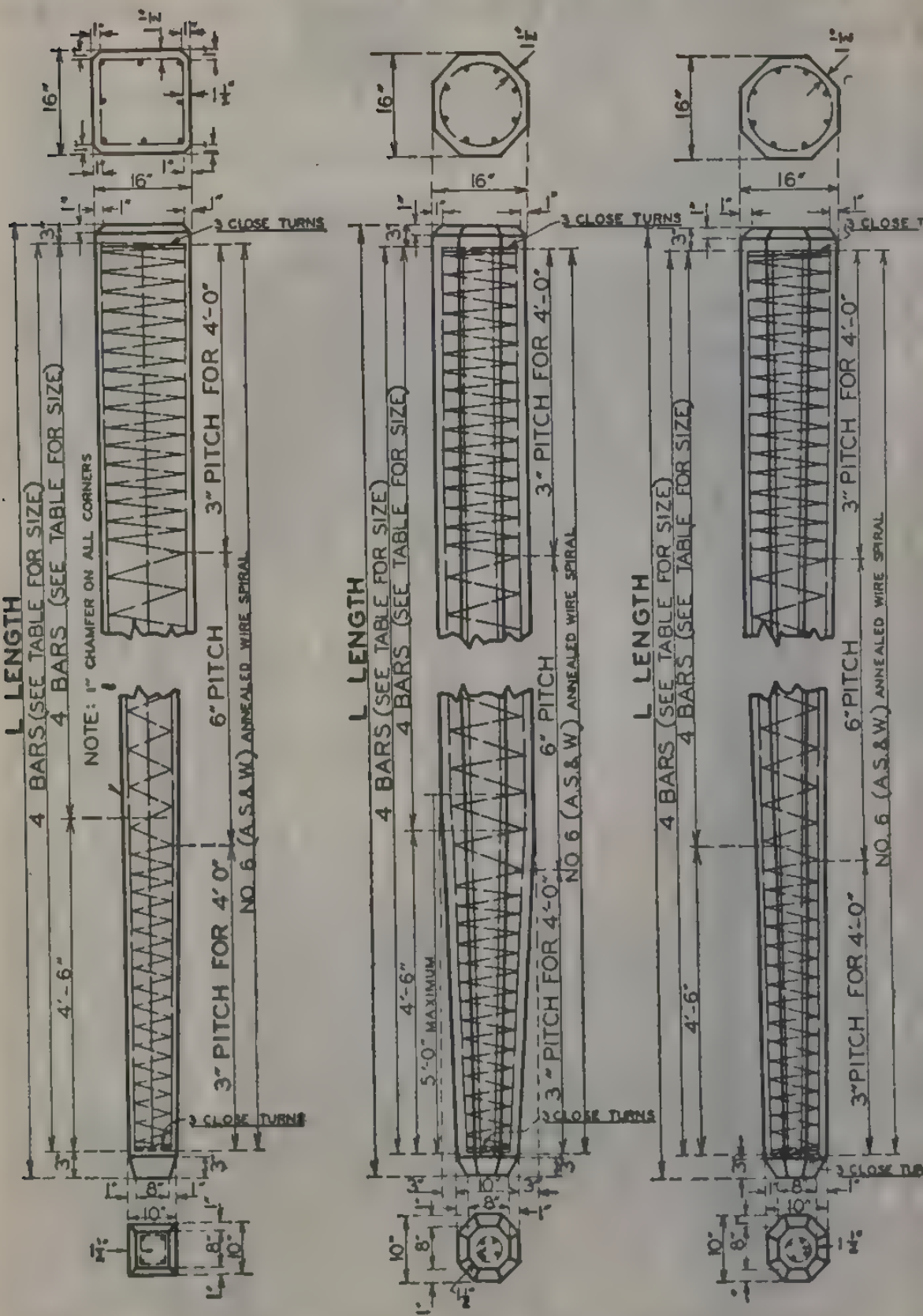
The above setting-up and dismantling costs apply to average equipment. On small jobs, a lift crane fitted with pile driving leads and hammer usually can do the job and the cost of moving in and out can be reduced from ½ to ⅔ the above cost. On large jobs with heavier and more costly equipment the above labor costs may be doubled.

Labor Driving Concrete Piles.—After the pile driver has been set up ready to operate, the number of piles driven per day and the labor cost driving same will vary with the length of the piles and job conditions. For instance, on a job where the piles were closely spaced and driven from a flat surface, a pile driver averaged 100 piles a day (which is exceptional), while on another job for the same owners, but where the piles were more widely scattered and had to be driven from different elevations, it was with difficulty that 20 piles were driven per day.

A good average for heavy precast piles is about 10 piles per 8-hr. day.

Raymond tapered piles in which the shell is left in the ground can usually be placed at the rate of 20 to 30 piles per day, but other types of cast-in-place piles are usually placed at a slower rate, averaging 10 to 20 piles per 8-hr. day. Under favorable job conditions all of these averages may be considerably increased.

The above time does not include supervision, laying out work or "spotting" piles, pumping, shoring, excavating, etc., but includes only the actual time driving the piles. Neither does it include cost of fuel, oil and other supplies, equipment charge, etc., which must be included in the estimate.



Various Types of Precast Concrete Piles

Cu. Ft. of Concrete in Concrete Piles of Various Sizes

Length in Ft.	8″-23″ Tapered Cu. Ft.	Diameter of Concrete Pile in Inches 13″ Cu. Ft.	15″ Cu. Ft.	16″ Cu. Ft.
1	0.4	.92	1.23	1.4
12	7.5	11	14.8	16.8
15	10.5	13.8	18.4	21
18	14.0	16.6	22.1	25.2
20	17.0	18.4	24.6	28
22	20.0	20.2	27	30.8
25	25.0	23	30.7	35
28	30.0	25.8	34.4	39.2
30	35.0	27.6	36.9	42
33	42.0	30.4	40.6	46.3
35	47.0	32.2	43	49
38	55.0	35	46.7	53.2
40	61.0	36.8	49.2	56

Shaft diameters are also driven in sizes of 15″ and 16″ for their full lengths.

Prices of Concrete Piles.—As mentioned previously, the cost of concrete piles will vary considerably depending upon the size of the job and the number of piles to be driven. This will vary from $3.75 per lin. ft. for a large job up to $5.00 or $6.50 per lin. ft. for a small job of 75 to 100 piles, plus the item of plant charges, transportation, etc., amounting to $4,000.00 to $5,000.00.

Short piles usually cost more per lin. ft. than long piles, however, it is the total footage on the job that controls the pile price rather than the lengths of the individual piles.

Prices of Composite Wood and Concrete Piles.—The same conditions apply to composite wood and concrete piles as given above for concrete piles, viz., it is the total footage on the job that controls the price rather than the length of the individual piles.

The cost of composite piles is also influenced by the relative lengths of the concrete and the wood section. The concrete section is comparatively expensive and the wood section is comparatively cheap. A safe estimating figure for wood sections would be about $2.55 per lin. ft. and for the concrete sections, about $4.50 per lin. ft.

In addition, add the item for plant charges, transportation, etc., amounting to $4,000.00 to $5,000.00.

The cost of a composite pile job will therefore depend on the total footage involved, as well as on the relative lengths of the wood and concrete sections.

Prices of Precast Concrete Piles.—On precast concrete pile work the prices per lin. ft. vary in a different manner from the price ranges for cast-in-place concrete piles and for composite piles. The longer the precast pile, the greater must be its cross section so that it can be handled. A precast concrete pile 14" square could be used in lengths up to about 40'-0", but for lengths of 100'-0", the precast pile has to be from 1'-8" to 2'-0" square. In addition, the very long precast piles require exceedingly heavy equipment. Accordingly the range of prices per lin. ft. of precast piles increases with the pile length.

After the item for plant charges, transportation, etc., amounting to $4,000.00 to $6,000.00, the cost of precast concrete piles will vary from $6.00 or $7.00 per lin. ft. for piles up to 40'-0" long to $15.00 per lin. ft. for piles 100'-0" long.

Driving 22'-6" Concrete Piles.—A nine story building erected in Chicago required 157 concrete piles 22'-6" long. The usual pile driving crew of 8 men was required.

After the pile driver had been delivered at the building site it required 4 days time for the crew to set up the driver, ready to start driving and after the job had been completed, it required 2½ days' time for the crews to dismantle the driver ready to be removed from the job.

To drive 157 concrete piles 22'-6" long, required 6¼ days actual time for the crew, as follows:

Setting up Pile Driver	Hours	Rate	Total	Rate	Total
Foreman	32	$.....	$.....	$6.30	$ 201.60
Engineer	32	.....	.....	6.20	198.40
Oiler	32	.....	.....	5.10	183.60
Linesman	32	.....	.....	6.00	192.00
Four pile driver men	128	.....	.....	6.00	768.00
Driving Piles					
Foreman	50	.....	.....	6.30	315.00
Engineer	50	.....	.....	6.20	310.00
Oiler	50	.....	.....	5.10	255.00
Linesman	50	.....	.....	6.00	300.00
Four pile driver men	200	.....	.....	6.00	1,200.00
Dismantling Pile Driver					
Foreman	20	.....	.....	6.30	126.00
Engineer	20	.....	.....	6.20	124.00
Oiler	20	.....	.....	5.10	102.00
Linesman	20	.....	.....	6.00	120.00
Four pile driver men	80	.....	.....	6.00	480.00
Insurance, Soc. Security, Unemp. Comp.		.....	.....		731.34
Labor cost 157 piles	816		$.....		$5,606.94

Cost per 22′-6″ pile	$35.71
Cost per lin. ft.	1.59

The above does not include pile contractor's overhead expense and profit.

A pile driver averaged 3½ piles (71 lin. ft.) an hr. or 25 (568 lin. ft.) piles per 8-hr. day.

Driving 20′-0″ Concrete Piles.—On a 12 story reinforced concrete building requiring 280 concrete piles 20′-0″ long, the following costs were obtained.

There was considerable broken time on this job, due to bad weather, and while the job required 17½ days, only 112 hrs. actual driving time was required. This included moving the pile driver from one place to another, as some of the piles were driven from the street level and others from the basement floor level.

The pile driving crew averaged two 20′-0″ concrete piles an hr. or 16 piles (320 lin. ft.) per 8-hr. day, at the following labor costs:

Setting up Pile Driver	Hours	Rate	Total	Rate	Total
Foreman	32	$.....	$.....	$6.30	$ 201.60
Engineer	32	.....	.....	6.20	198.40
Oiler	32	.....	.....	5.10	183.60
Linesman	32	.....	.....	6.00	192.00
Four pile driver men	128	.....	.....	6.00	768.00
Driving Piles					
Foreman	140	.....	.....	6.30	882.00
Engineer	140	.....	.....	6.20	868.00
Oiler	140	.....	.....	5.10	714.00
Linesman	140	.....	.....	6.00	840.00
Four pile driver men	560	.....	.....	6.00	3,360.00
Dismantling Pile Driver					
Foreman	20	.....	.....	6.30	126.00
Engineer	20	.....	.....	6.20	124.00
Oiler	20	.....	.....	5.10	102.00
Linesman	20	.....	.....	6.00	120.00
Four pile driver men	80	.....	.....	6.00	480.00
Insurance, Soc. Security, Unemployment Comp.		.....	.....		1,373.94
Labor cost 280 piles	1,536	$.....	$.....		$10,533.54
Cost per 20′-0″ pile			.....		$37.62
Cost per lin. ft.			.....		1.88

The above does not include pile contractor's overhead expense and profit.

Mixing and Placing Concrete in Concrete Piles.—The abov job required about 4,760 cu. ft. or 176 cu. yds. of concrete.

A gang of 4 men operating a 1-sack mixer worked the sam hours as the pile driver and mixed and placed the concrete a the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	3.2	$.....	$.....	$5.00	$16.00

Labor Mixing and Placing Concrete For Piles.—Practicall 90 percent of all concrete used in concrete piles is ready-mi concrete, which requires only labor taking same from trucks t place of deposit. Ordinarily it requires ¾ to 1¼ hours time fo one man per cu. yd. of concrete.

In the exceptional case where the concrete is job mixed, small mixer of 1 or 2 sacks capacity is generally used, as onl a small amount of concrete is required to keep up with the pil driver.

Only a few men are required in the mixing gang and it wi require 2¾ to 3¼ hrs. labor time per cu. yd. of concrete, as follows

	Hours	Rate	Total	Rate	Total
Labor	3	$.....	$.....	$5.00	$15.00

Prices of Steel H-Beam Piles.—Prices of steel H-beam pile vary considerably, mainly due to the material cost of the rolle steel sections. Steel sections commonly used for this purpos may range from an 8-inch H-section weighing 36 lbs. per lin. f to a 14-inch H-section weighing 117 lbs. per lin. ft.

Assuming a unit cost of 12 cents per lb., delivered to job si from warehouse, the H-beam material will cost from $4.32 t $14.04 per lin. ft. If direct mill shipment, savings up to 2 cen per lb. may be gained. If job is in an isolated location, additior al transportation charges must be figured.

Under average conditions, the cost of driving steel H-bea piles will vary from $1.00 to $1.25 per lin. ft., not including movin the equipment on and off the job or contractor's overhead an profit.

CHAPTER VI

CONCRETE BREAKING, EXCAVATING, WRECKING, SANDBLASTING, DRILLING, ETC. BY COMPRESSED AIR

Compressed air is used so extensively on all classes of construction work that the progressive contractor finds new uses for it daily in such operations as concrete breaking, masonry chipping, wrecking old buildings, excavating, tamping, sawing, painting, cement gun work, cutting off piling, driving sheet piling, cleaning and repairing buildings, laying concrete, trenching, etc.

The following data on compressed air has been collected from various sources, believed to be accurate. The information regarding sizes of portable compressors, and, also, regarding the performance of air operated tools has been furnished through the courtesy of Ingersoll-Rand Company, who will gladly furnish additional information, prices, etc., on all kinds of pneumatic equipment upon request.

The following will give an idea of the size of portable compressors now available. All sizes figured are on the basis of actual delivery of the compressor, i. e., the 105 foot size has an actual delivery of 105 cu. ft. of free air per minute, when operating at 100 lbs. per sq. in. pressure. Sizes available:

60 cu. ft.	105 cu. ft.	250 cu. ft.	600 cu. ft.
75 cu. ft.	125 cu. ft.	365 cu. ft.	900 cu. ft.
85 cu. ft.			1,200 cu. ft.

Various types of mountings are available for these portable compressors. All units can be furnished less wheels and axles; with four steel wheels or with pneumatic tires. The 60, 85, 105 and 160 cu. ft. sizes are available on two wheel pneumatic tire mountings. All but the 60 cu. ft. can be mounted on four wheel trailers. Many sizes can be furnished mounted on standard trucks. The type of mounting selected depends upon the contractor's requirements for speed of towing, etc.

To arrive at the accurate cost of performance and class of work, it will be necessary to obtain some idea of the cost of equipment, interest on investment, depreciation, repairs, etc.

As a basis for figuring depreciation, five years will be assume as the average life of a compressor unit; 5% of cost for interes on the investment, and $250.00 per year for repairs, miscellaneou supplies, etc. Gasoline and lubricating oils will be figured o the basis of 75 cts. per hr. per 100 cu. ft. for compressor and tool

As an example, take the following: the 80 cubic foot portabl mounted on pneumatic tires, is a popular machine and will oper ate several tools.

The cost of air tools varies considerably, but hand-held ham mer drills are priced from $355.00 to $650.00 depending upo size and weight while paving breakers vary from $320.00 to $620.0

Approximate cost of compressor unit.....		$4,000.00
Air tools, hose, etc.....		1,000.00
Total cost outfit		$5,000.00
Annual depreciation 20% for 5 years.....$1,000.00		
Interest on investment, 5% on $5000.00...	250.00	
Repairs, tools, etc.	250.00	
Annual fixed operating cost.....		$1,500.00

The average contractor will not have use for this machin every day, but based on approximately 100 operating days pe year, the fixed operating cost would run about $15.00 per day c $1.87 per hr. Lubricating oils, fuel, misc. supplies, etc., figured a $1.33 per hr. making a total operating cost of $3.20 per hr. fo each compressor unit.

Operating Costs on Compressed Air Units.—To reduce op erating and overhead costs to a minimum, two tools shoul be operated from each compressor, otherwise the fixed charge such as depreciation, interest, repairs, etc., will run rather hig per unit.

The costs given on the following pages are based on usin two tools with each compressor unit. It should be borne in min that the performance data is approximate only as job condition may cause considerable variation in hourly or daily output. Th wage rates quoted are used only as a guide in working out vari ous examples. Insert wage rates applicable in your locality.

Breaking Pavements Using Pneumatic Concrete Breakers.— Costs on this work will vary with the hardness and thickne of the concrete, but on a pavement consisting of 6" concrete an 1½" to 2" of asphalt, 2 men operating concrete breakers and on compressor operator should break up 450 to 550 sq. ft. of pave ment per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Jackhammerman	3.2	$.....	$.....	$5.25	$16.70
Compressor operator.	1.6	.....	.....	5.50	8.80*
Compressor expense .	1.6	.....	.....	3.20	5.12
Cost per 100 sq. ft..	4.8		$.....		$30.62
Cost per sq. ft.....			.....		.306

*Add only if required.

Comparative Cost by Hand

Working by hand, 3 men using wedges, sledge hammers, bars and picks should break up 75 to 85 sq. ft. of 6″ pavement per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	30	$.....	$.....	$5.00	$150.00
Cost per sq. ft.			.....		1.50

Cutting Out Concrete Foundations and Retaining Walls Using Pneumatic Concrete Breakers.—It is little more difficult to estimate the cost of cutting out heavy concrete walls, as so much depends upon the hardness of the concrete and the amount of reinforcing steel. However, on unreinforced 1:3:5 concrete

Breaking Pavements Using Pneumatic Concrete Breakers.

such as used for ordinary foundations, 2 jackhammermen should cut out 225 to 275 cu. ft. of concrete per 8-hr. day, at the following cost per 100 cu. ft.:

	Hours	Rate	Total	Rate	Total
Jackhammerman	6.4	$.....	$.....	$5.25	$33.40
Compressor operator ..	3.2	.....	.....	5.50	17.60*
Compressor expense ..	3.2	.....	.....	3.20	10.24
Cost per 100 cu. ft...	9.6		$.....		$61.24
Cost per cu. ft.....			.....		.612

*Add only if required.

Comparative Cost by Hand

Working by hand, 2 men using a sledge and a bull point should cut out 25 to 35 cu. ft. of concrete per 8-hr. day, at the following labor cost per 100 cu. ft.:

	Hours	Rate	Total	Rate	Total
Labor	52	$.....	$.....	$5.00	$260.00
Cost per cu. ft.....					2.60

Drilling Rock Using Pneumatic Jackhammer Drills.—The hand held jackhammer has become a very popular tool for rock drilling on all types of construction jobs. Because they are furnished in sizes weighing from 30 lbs. to 80 lbs., many rock drilling conditions can be met. Holes up to 20 ft. in depth are easily drilled with the heavier machines. Most sizes of jack-

Breaking Out Concrete Foundations Using Pneumatic Paving Breakers.

Rock Drilling Using Pneumatic Jackhammer Drills

hammers can be furnished in three styles depending upon the conditions of drilling and the depth of holes being drilled, these being the dry style for shallow holes, blower style for deep holes, and wet for jobs where dust must be kept down to a minimum.

Hollow drill steel of various sizes and shapes are used, the most common being $\frac{7}{8}$" and 1" hexagon. Bits are sometimes forged on the steel but the detachable bit is by far the most widely used.

When drilling holes in rock for trenches, blasting etc., two men operating drills should drill 125 to 175 lin. ft. of holes per 8-hr. day, at the following cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Jackhammerman	11.0	$.....	$.....	$5.25	$ 57.75
Compressor operator	5.5	.....	.....	5.50	30.25*
Compressor expense	5.5	.....	.....	3.20	17.60
Cost per 100 lin. ft.	16.5		$.....		$105.60
Cost per lin. ft.			$.....		1.06

Comparative Cost by Hand

When drilling holes in rock by hand, 2 men working together will drill only 12 to 15 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Labor	118	$.....	$.....	$5.00	$590.00
Cost per lin. ft.			.....		5.90

Rock Drilling Using Wagon Drills.—Wagon drills consist of a one piece tubular frame on pneumatic or steel wheels and tilting tower upon which is mounted a heavy pneumatic drill. They are recommended for drilling holes downward at any angle from the horizontal to the vertical to depths of 25 to 30 feet. This type of drill is suitable for all kinds of excavation and trenching work and will usually do the job of at least 2 to 3 heavy hand held jackhammers and requires only one operator.

Based on drilling 150 to 225 lin. ft. of holes per 8-hr. day, 100 lin. ft. of holes should cost as follows:

	Hours	Rate	Total	Rate	Total
Jackhammerman	4.3	$.....	$.....	$5.25	$22.58
Compressor operator	4.3	.....	.....	5.50	23.65*
Compressor expense	4.3	.....	.....	3.20	13.76
Cost per 100 lin. ft.	8.6		$.....		$59.99
Cost per lin. ft.			.....		.60

Rock Drilling Using Crawler Mounted Drills.—An innovation in rock drilling for blast holes, etc. is the completely mechanized, self-propelled drill unit. Many of the construction machinery manufacturers are now making such units. These units will do the work of two or three wagon drills and are taking over the field. The unit can move easily over rugged terrain and can tow

*Add only if required.

Crawler Mounted—Self-Propelled Drill—Drilling Rock

its own air supply with it. The set-up time for each hole is greatly reduced because of the self-propelled features. It is not uncommon

for a crawler mounted drill to drill more than 500 lineal feet per 8-hour shift in hard sedimentary rock.

Excavating Using Pneumatic Diggers.—These tools can be used to advantage on all classes of excavation that requires picking of dirt, clay, etc., such as trench work, tunneling, caisson sinking and all kinds of building excavation; in fact, on all kinds of work in stiff clay or hard ground where power shovels, trenching machines, etc., cannot be used.

On work of this kind, two men using air picks and six men shoveling will loosen and shovel 35 to 40 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor operating picks.	0.4	$.....	$.....	$5.00	$2.00
Labor shoveling	1.3	.....	.....	5.00	6.50
Compressor operator...	0.2	.....	.....	5.50	1.10*
Compressor expense ...	0.2	.....	.....	3.20	.64
Cost per cu. yd.....	1.9		$.....		$10.24

*Add only if required.

On larger excavations providing plenty of room for the men to work, a man with pneumatic pick will loosen 25 to 30 cu. yds.

Excavating Using Pneumatic Diggers and Concrete Breakers.

per 8-hr. day. After the clay or earth is loosened, a man will shovel 6 to 7 cu. yds. per 8-hr. day.

Comparative Cost by Hand

Excavating in stiff clay or tough ground, a man using a hand pick and shovel will loosen 2½ to 3 cu. yds of dirt per 8-hr. day. The same man, picking only, will loosen 3½ to 4 cu. yds. of dirt per 8-hr. day, and when shoveling only, will remove 6 to 7 cu. yds. per 8-hr. day.

Using a hand pick, a man will loosen and shovel one cu. yd. of dirt at the following cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	3	$.....	$.....	$5.00	$15.00

In large trenches or pits providing plenty of room to work, a man will loosen with a hand pick 6 to 7 cu. yds. of stiff clay or tough ground per 8-hr. day.

Backfill Tamping Using a Pneumatic Tamper.—A pneumatic tamper enables a workman to do nearly 10 times the amount of work he can do by hand. A backfill tamper strikes over 600 hard, snappy blows a minute, rams the fill hard, and works in

Backfill Tamping Using a Pneumatic Tamper

and around pipe with far greater thoroughness than hand devices are able to do.

In piers, trenches, etc., where the excavated earth can be shoveled directly into the trench, a man should backfill 16 to 20 cu. yds. per 8-hr. day.

Where the trenches have to be tamped, one man with a pneumatic tamper will tamp as much as 2 men can backfill, or approximately 35 to 40 cu. yds. per 8-hr. day.

The cu. yd. cost should average as follows:

	Hours	Rate	Total	Rate	Total
Labor backfilling	0.4	$.....	$.....	$5.00	$2.00
Labor tamping	0.2	.....	.....	5.00	1.00
Compressor operator..	0.2	.....	.....	4.50	.90*
Compressor expense ..	0.2	.....	.....	3.20	.64
Cost per cu. yd.....	0.8		$.....		$4.54

Comparative Cost by Hand

A man will tamp by hand 8 to 10 cu. yds. of backfill per 8-hr. day, at the following cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor backfilling	0.4	$.....	$.....	$5.00	$2.00
Labor tamping	0.8	.....	.....	5.00	4.00
Cost per cu. yd.....	1.2		$.....		$6.00

Clay Tunnel Excavating with Pneumatic Diggers.—In tunnel work through clay, a man with a pneumatic digger will loosen 9 to 11 cu. yds. per 8-hr. day, depending upon the toughness of the clay and the working space, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor digging	0.8	$.....	$.....	$5.35	$4.28
Compressor operator..	0.4	.....	.....	5.50	2.20*
Compressor expense ..	0.4	.....	.....	3.20	1.28
Cost per cu. yd.....	1.2		$.....		$7.76

Comparative Cost by Hand

When tunneling through clay, using a hand pick and shovel, a man will loosen 3 to 4 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	2.3	$.....	$.....	$5.00	$11.50

Excavating Frozen Ground Using Pneumatic Picks.—When picking frozen sand, loam or clay with a pneumatic pick, one

*Add only if required.

Deep Foundation and Caisson Excavating

man should loosen 250 to 300 cu. ft. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor operating pick..	0.8	$.....	$.....	$5.25	$4.20
Labor throwing out ...	1.0	.....	.....	5.00	5.00
Compressor operator..	0.4	.....	.....	5.50	2.20*
Compressor expense ..	0.4	.....	.....	3.20	1.28
Cost per cu. yd.....	2.2		$.....		$12.68

*Add only if required.

Comparative Cost by Hand

One man will pick and loosen only 30 to 50 cu. ft. of frozen sand, loam or clay per 8-hr. day, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Labor picking	6	$.....	$.....	$5.00	$30.00
Labor throwing out ...	1	.....	.....	5.00	5.00
Cost per cu. yd.....	7		$.....		$35.00
Cost per cu. ft.....			$.....		1.30

Breaking Out Masonry Walls by Compressed Air.

Excavating for Caissons with Pneumatic Diggers.—When excavating for caissons 5′-0″ to 8′-0″ in diameter and up to 100′-0″ deep, a man with a pneumatic digger will loosen and load into buckets 9 to 11 cu. yds. per 8-hr. day, depending upon the toughness of the clay and the working space, at the following cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor operating digger and loading buckets	0.90	$.....	$.....	$5.35	$3.92
Compressor operator	0.45	.....	.....	5.50	2.48*
Compressor expense	0.45	.....	.....	3.20	1.44
Cost per cu. yd.	1.35		$.....		$7.84

*Add only if required.

Comparative Cost by Hand

When excavating caissons by hand, two "diggers" will loosen and load into buckets, 8 to 10 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor excavating	1.8	$.....	$.....	$5.35	$9.63

Cleaning Paving Brick Using Pneumatic Chipping Hammers. A satisfactory method of cleaning brick with pneumatic chipping hammers is to use a 4"x12" plank about 10'-0" long, placed on 2 carpenters' horses and raised at one end 15 to 18 degrees. This is used to hold the brick which may be placed lengthwise across the plank, so that one side and one end can be cleaned without moving. A plank will hold about 56 brick. Using a pneumatic chipper with a hexagon nozzle and a 2" chisel bit, a man should clean 150 to 180 brick an hr. or 1,200 to 1,440 per 8-hr. day. One man turned the brick and kept the board full while the other man cleaned them.

The labor cost per 1,000 bricks was as follows:

	Hours	Rate	Total	Rate	Total
Hammer operator	6	$.....	$.....	$5.25	$31.50
Labor helping	6	.....	.....	5.00	30.00
Compressor operator	3	.....	.....	5.50	16.50*
Compressor expense	3	.....	.....	3.20	9.60
Cost per 1,000 bricks	15		$.....		$87.60

Comparative Cost by Hand

When cleaning paving brick by hand, a man will clean only 50 to 55 brick an hr. or 400 to 440 per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Labor	19	$.....	$.....	$5.00	$95.00

Wrecking Brick Buildings Using Pneumatic Tools.—When wrecking brick buildings, using pneumatic picks for loosening the brick in the walls, a gang consisting of 4 men (2 pick operators and 2 helpers), should remove about 5,000 brick an hr. (1,250 per hr. per man) at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Pick operator	0.4	$.....	$.....	$5.25	$2.10
Helper	0.4	.....	.....	5.00	2.00
Compressor operator	0.2	.....	.....	5.50	1.10
Compressor expense	0.2	.....	.....	3.20	.64
Cost per 1,000 brick.	1.0		$.....		$5.84

Comparative Cost by Hand

Wrecking the same class of buildings by hand, a man will remove only 350 to 375 brick an hr. or 2,800 to 3,000 per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Labor wrecking	2.75	$.....	$.....	$5.00	$13.75

SANDBLAST CLEANING OF BUILDINGS

The portable compressor and the sandblast are widely used for cleaning buildings, bridges and other structures, either

*Add only if required.

preparatory to repainting or for the purpose of brightening up the surface.

The cost of this work, however, is contingent entirely upon the condition of the old buildings, as some of them have nothing more than many years' accumulation of dirt while others have been painted numerous times, making it necessary to remove several coats of paint before the surface of the brick or stone can be touched. Also, it is often necessary to repoint all of the old mortar joints. The estimator should consider all of these items when preparing the estimate.

The process of sandblasting is to force sand against the surface to be cleaned through a small hose connected with the air compressor, and the force of the sand striking the object to be cleaned removes the old surface. Where it requires a maximum pressure of sand and air to remove the old dirt, a ¾" hose is used but where volume is desired more than high pressure a 1" hose is used.

It usually requires four men to operate a sandblasting machine, as follows: one man attending the machine, one man at the nozzle, and two men on the ground assisting with hose, scaffold, sand, etc.

When estimating quantities, take the entire area of the surface to be cleaned, make no deductions for door or window openings.

On court houses, state capitols, post offices, public libraries, and other ornamental structures, the quantities are computed as above and in addition, balustrades, balusters, etc., are measured on both sides, as it is necessary to go around each baluster separately to clean it.

With a portable compressor supplying air, the average operator can cover a strip 25'-0" wide and 60'-0" to 75'-0" high per 8-hr. day. The exact area varies with the quality of the stone encountered but the following table shows the speed at which various stones can be cleaned.

	Sq. Ft. per Min.		Sq. Ft. per Min.
Limestone	7 to 9	Terra Cotta	8 to 10
Marble	3 to 5	Brick or Brownstone	8 to 10
Granite	6 to 8	Sand stone	10 to 12

The quantity of sand required for sandblasting will vary with the method used but where a canvas screen or covering surrounding the scaffold catches most of the sand, it is then carried back to the tank on the ground. If this is done about 75% of the sand is saved for use again. This, however, is governed somewhat by the conditions of the work.

The following costs are for removing and cleaning only the natural accumulation of dirt, and do not include removing paint, oil stains, etc., unless otherwise mentioned.

Maximum quantities are not figured in the tables as average job conditions usually include delays, moving from one job to another, placing and removing scaffold, etc.

Cost of Sandblasting 100 Sq. Ft. of Old Brick or Limestone Buildings.

	Hours	Rate	Total	Rate	Total
Compressor Operator	0.33	$.....	$.....	$5.50	$ 1.83*
Nozzleman	0.33	.....	.....	6.25	2.08
Labor	0.67	.....	.....	5.00	3.34
Compressor expense	0.33	.....	.....	3.20	1.07
5 cu. ft. sand		.....	.....	.60	3.00†
Hose, nozzles, etc.		.....	.....	.80	.80
Cost per 100 sq. ft.	1.33		$.....		$12.12
Cost per sq. ft.					.121

Add for tuckpointing contractor's overhead and profit.

Sandblasting Old Brick Work That Has Been Painted.—If the old brick work has been painted and the paint can be blasted off without the necessity of repointing the mortar joints, the costs will run about the same as given above for plain work.

Sandblasting Ornamental Buildings, Such as Post Offices, Court Houses, State Capitols, Public Libraries, Etc., Constructed of Granite or Limestone.—The cost of sandblasting buildings as enumerated above, having exterior elaborations, such as balustrades, gables, pediments, plain or fluted columns, etc., will be higher than plain buildings on account of the extra labor required for scaffolding, sandblasting balusters, columns, caps, etc., that are not found on the average building.

The cost per 100 sq. ft. of surface should average as follows:

	Hours	Rate	Total	Rate	Total
Compressor operator	0.67	$.....	$.....	$5.50	$ 3.66*
Nozzleman	0.67	.....	.....	6.25	4.16
Labor	1.33	.....	.....	5.00	6.67
Compressor expense	0.67	.....	.....	3.20	2.14
5 cu. ft. sand		.....	.....	.60	3.00†
Hose, nozzles, etc.			.....	.80	.80
Cost per 100 sq. ft.	2.67		$.....		$20.43
Cost per sq. ft.					.204

Add for tuckpointing contractor's overhead and profit.

*Add only if required.
†Based on using sand three times.

Repointing Mortar Joints After Sandblasting.—On many old buildings that are unusually dirty or that have been painted, it often happens that the mortar is blasted from the joints when removing the paint from the brick. After the job has been cleaned the tuckpointers must go over the entire surface and repoint all of the brick joints.

Installing Service Pipes.—Many public utility companies, instead of breaking up sidewalks and digging trenches, are installing service pipes by means of portable compressors and pneumatic tools. Where no rock is encountered it has been found possible to drive pipe directly through the earth and into cellars, basements, etc.

This method consists of placing a pointed steel cap over the end of the pipe, which can be removed after the pipe holes through.

The average time taken to drive a service pipe 25 to 30 ft. from curb to basement, was found to be approx. 35 minutes, depending upon condition of the soil, at the following cost per service, including drilling and all preliminary work:

	Hours	Rate	Total	Rate	Total
Jackhammerman	6	$.....	$.....	$5.25	$31.50
Compressor operator ..	3	.....	.....	5.50	16.50*
Compressor expense ..	3	.....	.....	3.20	9.60
Cost per service	9		$.....		$57.60
Cost per lin. ft.			.....		1.92

*Add only if required.

The cost of installing service pipes by hand, including cost of opening flagstones, etc., averaged 3½ to 4 times the above.

Caulking Gas and Water Pipes by Compressed Air.—It has been found that by using pneumatic hammers, a lead wool joint can be caulked in one-half the time required by hand work.

The adoption of lead wool for caulking gas pipe joints, etc., has almost entirely displaced hand methods in favor of pneumatic methods. The following time comparisons between caulking lead wool by hand and by air hammers will be of interest and are based on one man's work:

Diam. of Pipe Inches	Hand Caulking Hours	Air Caulking Hours
12	2	1
16	3	1½
20	4	2
24	6	2½
30	8½	3½

Caulking Gas and Water Pipes by Compressed Air—Cont'd.

Diam. of Pipe Inches	Hand Caulking Hours	Air Caulking Hours
36	10½	5
42	14	6½

Caulking Cast Lead Joints.—For cast lead type of joint, used in laying water pipe, the saving is practically the same as given above for lead wool joints.

Cleaning Rust and Scale Off Structural Steel by Compressed Air.—When cleaning rust and scale off of structural steel members, bridges, gas holders, oil tanks, and other metal surfaces before repainting, the number of sq. ft. cleaned per day will vary with the surfaces and the accessibility of same.

On structural steel members, bridges, etc., a man should clean 1,200 to 1,500 sq. ft. per 8-hr. day, using air operated wire brushes, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Painter	0.6	$.....	$.....	$6.00	$ 3.60
Compressor operator	0.3	.....	.....	5.50	1.65
Compressor expense	0.3	.....	.....	3.20	.96
Cost per 100 sq. ft.	0.9		$.....		$ 6.21
Cost per sq. ft.			$.....		.062

On gas and oil tanks and other large surfaces, a man should clean about 2,000 sq. ft. of surface per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Painter	0.4	$.....	$.....	$6.00	$ 2.40
Compressor operator	0.2	.....	.....	5.50	1.10
Compressor expense	0.2	.....	.....	3.20	.64
Cost per 100 sq .ft.	0.6	.....	$.....		$ 4.14
Cost per sq. ft.			.....		

Comparative Cost by Hand

When cleaning steel surfaces using hand operated wire brushes, a man will clean only 225 to 275 sq. ft. of surface per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Painter	3.2	$.....	$.....	$6.00	$19.20
Cost per sq. ft.	3.2		.....		.192

Painting by Compressed Air.—Almost any painting job can be done quicker with an air operated paint spray. This is particularly true where large surfaces are to be covered or where there are angles and corners that cannot be reached with hand brushes.

*Add only if required.

Practically all surfaces that are now being painted with a bristle brush can be coated by air painting. On rough surfaces such as cement, stucco, rough plaster, brick, tile, shingles and rough boards, air painting affects a considerable saving in time and labor as well as in the cost of brushes.

It is now possible to obtain mechanical painting equipment that will apply any paint, varnish, enamel, water paints, graphite, mineral oxides, red lead, etc.

Painting Oil Tanks and other Large Metal Surfaces by Compressed Air.—In painting oil tanks and other large metal surfaces, a man should cover 300 to 350 sq. ft. an hr. at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
0.13-gal paint		$.....	$.....	$6.00	$0.78
Painter	0.30	.....	.....	6.00	1.80
Compressor operator..	0.15	.....	.....	5.50	.83
Compressor expense ..	0.15	.....	.....	3.20	.48
Cost per 100 sq. ft...	0.60		$.....		$3.89
Cost per sq. ft.....			.....		.039

Comparative Cost by Hand

On the same class of work, a man will brush about 125 to 150 sq. ft. of surface an hr. at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
0.20-gal. paint		$.....	$.....	$6.00	$1.20
Painter	0.73	.....	.....	6.00	4.38
Cost per 100 sq. ft...	0.73	.....	$.....		5.58
Cost per sq .ft.			.....		.056

CHAPTER VII

CONCRETE FOOTINGS, FOUNDATIONS AND RETAINING WALLS

The information given in this chapter will prove of inestimable value to contractors, estimators, superintendents and foremen estimating or constructing all classes of concrete and concrete form work.

When estimating the cost of mass concrete, such as footings, foundations, retaining walls, etc., there are four distinct labor operations to be considered, in addition to the materials used.

The first operation is placing the concrete footings. If the footing extends for its full depth into solid ground and the banks are self supporting, a wood form should not be necessary unless specifically called for by the architect or engineer. Under similar ground conditions but where the footing only extends into the ground for part of its depth, a ribbon form, for the exposed portion is placed in the proper location, secured to stakes and set to the elevation required for the top of the footing, and then the balance of the footing depth is hand excavated between the ribbon forms. Where the ground conditions are such that trenches cannot be dug neat, the footing must be formed for its entire depth.

After the concrete footing has been placed it will be necessary to construct wood forms to support the wet concrete until it has "set" or hardened. On ordinary walls the forms may be removed as soon as the concrete is self-supporting, which is usually one or two days after concreting, except during freezing weather when three days should elapse before forms are stripped, providing the concrete has been protected against freezing for at least one or two days by covering with tarpaulins and heating by salamanders or steam.

Where reinforcing steel is required it is usually placed after one side of the wall has been formed.

The labor cost of mixing and placing the concrete is also a separate operation and should be estimated accordingly.

The complete estimate should include the following items:

1. Cost of concrete forms, including lumber, nails, tie wire, spacers, etc., together with labor cost erecting and removing forms.

2. Cost of reinforcing steel, if required. Should include cost of reinforcing steel or mesh, tie wire and labor cost of handling and placing.
3. Cost of concrete for footings and walls, including cement, gravel or crushed stone, sand, or ready-mix concrete, together with the cost of labor for mixing and placing concrete.
4. Finishing, curing, and protection in inclement or cold weather.

WOOD FORMS

Forms for concrete footings, foundation and retaining walls should be estimated by the sq. ft. taking the actual area of the concrete that comes in contact with the wood forms, except in the case of ribbon footing forms which are usually measured by the lineal foot of form placed.

Example: Find the number of sq. ft. of forms required for a wall 50'-0" long and 4'-0" high. Forms will be required for both sides of the wall, which is obtained as follows: $50 \times 4 \times 2 = 400$ sq. ft. of forms.

Forms for Concrete Footings.—There are two main types of footings which are used in most construction work, namely: column footings and wall footings. Column footings are usually square or rectangular masses of concrete designed to spread the column loading over an area to accommodate the soil bearing value and are located at the column centers of the structure. Wall footings are usually ribbons of concrete somewhat wider than the walls they carry and are similarly designed to spread the loading over a larger area than the actual wall bottom.

Forms for footings which are formed completely, are usually simple and rough, using 2" planking for sides and 2"x4" stakes to hold the sides in place and 2"x4" struts for braces to the banks. This material may be used 5 or 6 times in the course of the work.

Ribbon forms for partly formed footings usually consist of 2"x4" lumber in as long lengths as practicable, secured at the correct elevation to 2"x4" stakes and tied across the tops at intervals of 4'-0" to 6'-0" with 1"x2" spreader-ties, except in the case of column footings which are usually diagonally tied at the corners with 1-inch boards and tied transversely, if required, with strap iron.

The following are itemized costs of the column and wall footing forms found in the average simple job. Complicated or "cut-up" jobs require up to 25 percent more material and up to 50 percent more labor.

Cost of 100 Sq. Ft. of Column Footing Forms Based on Footings 5′-0″x5′-0″x1′-6″ Completely Formed

Material	Ft. BM	Rate	Total	Rate	Total
Sides, 2″ planking	206	$.....	$.....	$0.025*	$ 5.15*
Stakes and braces, 2″x4″	100	.....	.....	.025*	2.50*
Nails, strap iron, etc.		.....	.....	1.20	1.20
Placing Forms—18-22 sq. ft. per hr.	Hours				
Carpenter	5.0	.....	.....	6.75	33.75
Labor helping	2.5	.....	.....	5.00	12.50
Stripping Forms—90-110 sq. ft. per hr.					
Labor	1.0	.....	.....	5.00	5.00
Cost per 100 sq. ft.	8.5	.....	$.....		$60.10
Material cost per sq. ft.			.....		.09
Labor cost per sq. ft.			.....		.51

Cost of 100 Lin. Ft. of Column Footing Ribbon Forms Based on Footings 5′-0″x5′-0″x1′-6″ Partly Formed

Material	Ft. BM	Rate	Total	Rate	Total
Ribbons, 2″x4″, 100 Lin. Ft.	67	$.....	$.....	$0.025*	$1.68*
Stakes, 2″x4″, 3′-0″ long	80	.....	.....	.025*	2.00*
Corner ties, 1″x6″, 2′-0″ long	20	.....	.....	.02*	.40*
Nails, strap iron, etc.		.....	.....	1.00	1.00
Placing Forms—18-22 Lin. Ft. per hr.	Hours				
Carpenter	5.00	.....	.....	6.75	33.75
Labor helping	2.50	.....	.....	5.00	12.50
Stripping Forms—450-500 Lin. Ft. per hr.					
Labor	0.21	.....	.....	5.00	1.05
Cost per 100 Lin. Ft.	7.71	.....	$.....		$52.38
Material Cost per Lin. Ft.			.....		.05
Labor Cost per Lin. Ft.			.....		.47

Cost of 100 Sq. Ft. of Wall Footing Forms Based on Footings 1′-0″ Deep Completely Formed

Material	Ft. BM	Rate	Total	Rate	Total
Sides, 2″x12″ planks	200	$.....	$.....	$0.025*	$ 5.00*
Stakes and braces	75	.....	.....	.025*	1.88*
Nails, strap iron, etc.		.....	.....	.75	.75
Placing Forms—25-30 sq. ft. per hr.	Hours				
Carpenter	3.50	.....	.....	6.75	23.62
Labor	1.75	.....	.....	5.00	8.75
Carried forward	5.25	.....	$.....		$40.00

*Based on 6 uses of lumber.

	Hours	Rate	Total	Rate	Total
Brought forward	5.25	$.....	$.....	$.....	$40.00
Stripping Forms—70-75 sq. ft. per hr.					
Labor	1.50	.....	.....	5.00	7.50
Cost per 100 sq. ft.	6.75		$.....		$47.50
Material cost per sq. ft.			.....		.08
Labor cost per sq. ft.			.....		.40

Cost of 100 Lin. Ft. of Wall Footing Ribbon Forms Based on Footings 1'-0" Deep Partly Formed

Material	Ft. BM	Rate	Total	Rate	Total
Ribbons, 2"x4", 100 lin. ft.	67	$.....	$.....	$0.025*	$ 1.68*
Stakes, 2"x4", 2'-0" long	33	.....	.....	.025*	.84*
Ties, 1"x2", 2'-0" long	4	.....	.....	.02*	.08*
Nails, etc.		.....	.....	.75	.75
Placing Forms—25-30 Lin. Ft. per hr.	Hours				
Carpenter	3.50	.....	.....	6.75	23.62
Labor helping	1.75	.....	.....	5.00	8.75
Stripping Forms—450-500 Lin. Ft. per hr.					
Labor	0.21	.....	.....	5.00	1.05
Cost per 100 Lin. Ft.	5.46		$.....		$36.77
Material Cost per Lin. Ft.			.....		.03
Labor Cost per Lin. Ft.			.....		.34

* Based on 6 uses of lumber.

On jobs where the wall footings are stepped down to a lower elevation, a riser form is required at each step. The cost of this riser form is about twice the cost of the regular footing side form.

Grooves are usually formed in the tops of footings and are called "Footing Keys." They are formed by forcing a beveled 2"x4" into the surface of the wet concrete. After the concrete has hardened the "key" forms are pried loose, cleaned and reused.

Cost of 100 Lin. Ft. 2"x4" Footing Keys

	Hours	Rate	Total	Rate	Total
100 lin. ft. 2"x4" strips.		$.....	$.....	$0.033*	$ 3.30*
Carpenter placing	1.25	.....	.....	6.75	8.44
Labor stripping	.50	.....	.....	5.00	2.50
Cost per 100 lin. ft.	1.75		$.....		$14.24
Material cost per lin. ft.			.....		.03
Labor cost per lin. ft.			.....		.11

* Based on 3 uses of lumber.

Forms for Pile Caps.—After piles are driven and cut off at the required elevation, they are capped with masses of concrete which are designed to transmit the total loading of the structure to the piles. These pile caps vary in size and shape from simple square

caps covering one pile to complex many sided caps covering clusters of twenty or more piles.

Forms for pile caps are usually prefabricated in panels at the bench and are then set up and put together in the pile location. Side forms up to 3'-0" wide are usually made up from 2" planking cleated together with 1"x4" or 1"x6" boards. Side forms over 3'-0" wide are constructed of 1"x6" D&M lumber on 2"x4" framing. Five or 6 uses can usually be obtained from these forms.

After panels are set in place they are secured with 2"x4" braces and tied with strap iron.

The following is an itemized cost of average pile cap forms, based on 5'-6"x5'-6"x3'-0", containing 66 sq. ft.:

Making Pile Cap Side Forms	Hours	Rate	Total	Rate	Total
12 pcs. 2"x10"-6'-0", 120 ft. bm.		$.....	$.....	$0.150	$18.00
4 pcs. 2"x8"-6'-0", 32 ft. bm.				.150	4.80
12 pcs. 1"x6"-3'-0", 18 ft. bm.				.120	2.16
4 pcs. 2"x4"-3'-0", 8 ft. bm.				.150	1.20
Nails				.50	.50
Carpenter	4			6.75	27.00
Labor	2			5.00	10.00
Cost per cap, 66 sq. ft.	6		$.....		$63.66
Cost per sq. ft.					.96
Material cost per sq. ft.					.39
Labor cost per sq. ft.					.57

Divide above sq. ft. costs by number of times forms may be used on the job.

Setting and Removing Pile Cap Forms

Bracing, 12 pcs.	Hours	Rate	Total	Rate	Total
2"x4"-10'-0", 80 ft. bm.		$.....	$.....	$0.025*	$ 2.00*
Nails, strap iron, etc.				1.00	1.00
Carpenter	6			6.75	40.50
Labor	3			5.00	15.00
Labor stripping, cleaning, moving	2			5.00	10.00
Cost per cap, 66 sq. ft.	11		$.....		$68.50
Cost per sq. ft.					1.04
Material cost per sq. ft.					.03
Labor cost per sq. ft.					1.01

*Based on 6 uses of lumber.

Forms for Concrete Piers.—When column footing tops are lower than the bottom of the floor slab on the ground, piers are usually designed to carry the column loading to the footings.

Forms for this work are usually made up in side panels at the job bench, hauled to the footings, erected, clamped and braced.

Side panels are usually made of 1"x6" D&M sheathing, cleated together with 1"x4" cleats. Clamping may be accomplished by using either 2"x4" lumber or metal column clamps properly spaced to withstand the pressure developed when placing the concrete.

Bracing is required to hold the form in position and usually consists of 2"x4" or 2"x6" lumber, secured to the form at grade level, spanning the pit and spiked to stakes driven into the ground. Bracing below this point is done by wedging 2"x4" struts between the form and the earth banks.

The following are itemized costs of average pier forms; based on a pier 2'-0"x2'-0"x4'-0" containing 32 sq. ft.:

Making Pier Forms	Hours	Rate	Total	Rate	Total
Sheathing, 1"x6" d&m, 39 ft. bm.		$.....	$.....	$0.120	$ 4.68
Cleats, 3 pcs. 1"x4"-8'-0", 8 ft. bm.		.....	.....	.12	.96
Nails, etc.		.....	.....	.15	.15
Carpenter	1.0	.....	.....	6.75	6.75
Labor	0.5	.....	.....	5.00	2.50
Cost 32 sq. ft.	1.5		$.....		$15.04
Cost per sq. ft.			.....		.47
Material cost per sq. ft.			.....		.18
Labor cost per sq. ft.			.....		.29

Divide sq. ft. costs by number of times forms may be used.

Erecting Concrete Pier Forms Using 2"x4" Lumber for Clamps

	Hours	Rate	Total	Rate	Total
Clamps, 8 pcs. 2"x4"-3'0", 16 ft. bm.		$.....	$.....	$0.025*	$ 0.40*
Bracing, stakes and struts, 65 ft. bm.		.....	.....	.025*	1.63*
Nails, etc.		.....	.....	.25	.25
Carpenter	2.0	.....	.....	6.75	13.50
Labor	1.0	.....	.....	5.00	5.00
Carried forward	3.0	.....	$.....		$20.78

*Based on 6 uses of lumber.

	Hours	Rate	Total	Rate	Total
Brought forward	3.0	$.....	$.....	$.....	$20.78
Stripping, including cleaning and moving Labor	0.5	.....	.....	5.00	2.50
Cost per pier, 32 sq. ft.	3.5		$.....		$23.28
Cost per sq. ft.			.....		.73
Material cost per sq. ft.			.....		.07
Labor cost per sq. ft.			.....		.66

Erecting Concrete Pier forms Using Metal Column Clamps

	Hours	Rate	Total	Rate	Total
†Rental, 2 column clamps		$.....	$.....	$0.05†	$ 0.10
Bracing, stakes and struts, 65 ft. bm.		.....	.....	.025	1.63*
Nails, etc.		.....	.....	.20	.20
Carpenter	1.75	.....	.....	6.75	11.81
Labor	.88	.....	.....	5.00	4.40
Stripping, including cleaning and moving Labor	.50	.....	.....	5.00	2.50
Cost per pier, 32 sq. ft.	3.13		$.....		$20.64
Cost per sq. ft.			.....		.65
Material cost per sq. ft.			.....		.06
Labor cost per sq. ft.			.....		.59

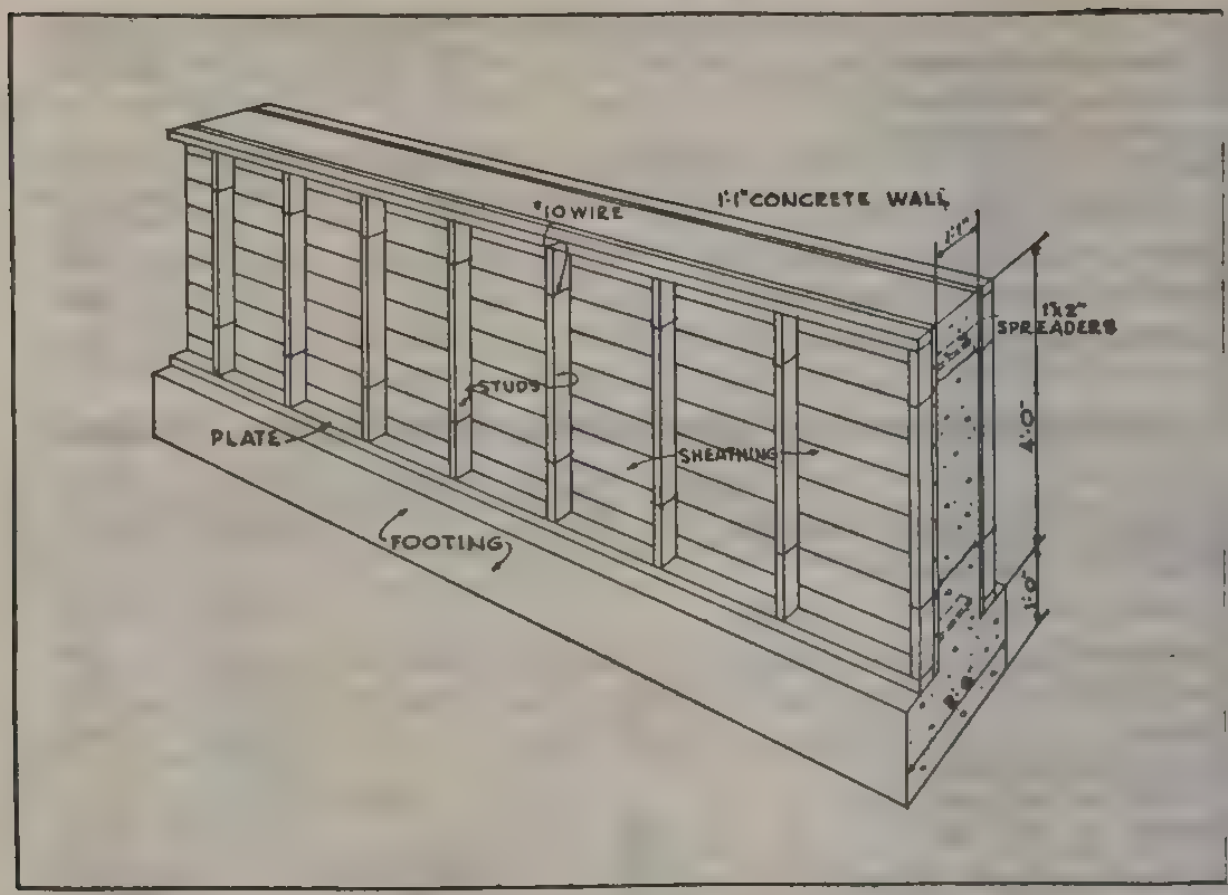
*Based on 6 uses of lumber.
†Based on 6 uses of clamps per month.

Forms for Concrete Walls

The labor and material costs per sq. ft. of forms will vary with the thickness and height of the wall, number of times the lumber may be used, etc. For average work it requires 2 to 3 ft. of lumber, b.m per sq. ft. of forms.

Concrete wall forms have all been designed in the best engineering practice, giving lumber requirements, stud, wale and bolt spacing for walls of any height up to 20 feet, so the contractor and estimator may see at a glance (without figuring), the amount of lumber, wales, bracing, tie rods, etc., required for walls of any height, including plywood, which is commonly used where smooth concrete surfaces are required.

Forms for concrete walls should be designed to withstand the horizontal pressure exerted by the concrete on the forms. There is some uncertainty as to the exact pressure exerted by freshly placed concrete, but experience, supported by some test data, indicates with sufficient accuracy for practical purposes the



Method of Constructing Wood Forms for Concrete Foundation Walls.

pressures that should be used for safe design. The pressure is influenced by the following factors:

1. Rate of filling the forms.
2. Proportions of the mix and its consistency.
3. Temperature of the concrete.
4. Method of placing the concrete whether by ordinary tamping or by internal vibration.

High frequency vibration is widely used as a means of placing structural concrete work, especially for heavy sections like dams, bridge piers, thick walls, etc. Tests show that vibration causes concrete to act as a fluid and the fluidity is retained during the vibration period. Thus the full height of concrete under vibration must be considered as the head, and the pressure is the same as for a liquid having the weight of concrete, or about 150 lbs. per cu. ft.

When concrete is compacted by hand, the agitation is not sufficiently rapid to maintain the mass in strictly a fluid condition for considerable heights. The pressures exerted are therefore somewhat less than the full hydrostatic head. Tests show that for each rate of placing, the pressure increases to a certain maximum and then decreases. The more rapid the placing rate, the

quicker the maximum pressure is attained, because the concrete becomes so compacted after it reaches a certain depth (variable depending upon the rate of placing) that it will support any additional depth of concrete without exerting additional pressure on the forms. This state is reached when placing at a rapid rate, before hardening of the concrete has begun; but for slower rates, probably under 2 feet per hour, the hardening of the concrete combines with the compaction to prevent further increase in pressure.

The temperature at which concrete is placed also has a marked influence on the maximum pressure attained and the elapsed time before it is reached. For example, mixtures placed at 70° F. develop maximum pressures equal to about 80 percent of those placed at 50° F. The following table gives conservative pressures for hand tamped concrete placed at 1 to 10 ft. per hour and at a temperature of 60° F. Forms of less depth than the depth at which maximum pressure is attained for the different rates of placing may be designed to withstand the lower pressures shown in the table.

In deep forms, that part below the depth of maximum pressure should be designed for the maximum pressure. Generally, building forms of such depths as to require that the bottom part be designed for the maximum pressure are constructed with the same spacing of studs and wales to the top. Some saving in material can be made in long, high walls by taking advantage of lower pressure near the top, but this is seldom of importance in ordinary buildings.

Pressure of Concrete Exerted on Wall Forms in Pounds Per Sq. Ft.

Based on a mixture of 1 :2½ :3½ concrete, measured by damp and loose volume, containing approximately 5½ sacks of cement per cu. yd. and about 6½ gallons of mixing water to each sack of cement, producing a concrete having a slump of 6½ to 7½ inches. Temperature of concrete 60° F.

For the same mixture of concrete having a slump of only 3" to 4", and for depths greater than 4'-0", the pressures are about 15 percent less than given in the above table.

For a mixture of 1 :2¾ :5 concrete (about 4½ sacks of cement per cu. yd.), using 8 gallons of water per sack of cement, producing a slump of about 7", pressures of concrete for a depth greater than 4'-0" are about 10 per cent less than given in the table. For the same mixture, using less mixing water to produce a slump of 3" to 4", the concrete pressures on the forms are reduced about 25 percent from the figures given in the above table.

Pressure of Concrete Exerted on Wall Forms in Lbs. per Sq. Ft

Depth of Concrete Below Top of Forms in Feet	Rate of Filling Forms, Feet per Hour — 10	6	4	2	1
1	150	150	150	150	150
2	300	300	300	300	300
3	410	410	410	410	410
4	530	540	550	500	380
5	630	630	630	580	
6	720	700	680	540	
7	750	730	650	440	
8	780	700	570		
9	760				
10	720				
11	680				

For concrete temperatures of:
100° F. Pressures are 25 percent less for all mixtures.
80° F. Pressures are 14 percent less for all mixtures.
70° F. Pressures are 6 percent less for all mixtures.
50° F. Pressures are 10 percent more for all mixtures.

The variation in pressures on account of temperature holds good for a depth greater than 2'-0" for 100° F. concrete; for greater than 3'-0" for 70° F.; and for greater than 4'-0" for 50° F. concrete.

When wall forms are filled so rapidly that only 30 minutes or less elapse for pouring the entire height of the forms, then, regardless of temperature, fluid pressure equivalent to a weight of 150 lbs. per cu. ft. will be exerted on the forms, and the pressure at any depth below the top will be equal to the depth in feet multiplied by 150 lbs. per sq. ft. Example: At 12'-0" below top of the forms, the pressure will amount to 12x150=1,800 lbs. per sq. ft.

When internal vibration is used and the vibrator element is 5'-0" below the top of concrete, the pressure of concrete will amount to about 800 lbs. per sq ft. somewhat below the depth of the element. As a rule, the vibrator element is not more than 2'-0" below the top of the concrete, in which case pressures of 600 lbs. per sq ft. will be exerted somewhat below the element and even comparatively shallow forms must be designed for this pressure. Pressures greater than 900 lbs. per sq. ft. are unlikely to be encountered when vibration is used, as the application of a vibrator is practical only for concrete slumps of 3" or less, where concrete pressures are 20 to 30 percent less than those given in

the table on account of the greater stiffness of the mixture and the earlier setting of the cement.

Items Affecting the Cost of Concrete Wall Forms.—After the number of sq. ft. of wall forms has been computed, it will be necessary to arrive at the labor and material cost of erecting and removing same.

These costs will be governed by the height of the wall because the higher the wall the more lumber required per sq. ft. of forms and the more bracing required to prevent the forms from spreading while the wet concrete is being placed.

The shape of the building is also important because it will be much easier and more economical to build forms for long straight walls than for irregular walls cut-up with bays, offsets, pilasters, etc., so the estimator should bear this in mind when preparing the estimate.

Concrete Wall Forms Made in Panels or Sections.—Many contractors, especially those performing smaller work, use foundation wall forms made up into panels 2′x6′, 2′x8′, 4′x6′ or 4′x8′ etc., in size. The frame for these sections is usually 2″x4″ lumber, with intermediate braces spaced 1′-4″ to 2′-0″ on centers. The corners are reinforced with galvanized straps or strap iron, and the entire frame is sheathed with 1″x6″ dressed and matched lumber or ¾″ plyform plywood.

It requires 2 ft of lumber, b.m. per sq. ft. of forms, exclusive of bracing, but forms of this kind can be used a large number of times, especially where the walls are fairly straight.

The labor cost of making panel forms will vary with the method used and the number made up at one time. If the lumber is delivered cut to exact length or if an electric saw is used on the job, a carpenter should complete one panel (28 to 32 sq. ft.) in ¾ to 1-hr. or 8 to 10 panels per 8-hr. day.

The following is an itemized list for one 4′-0″x8′-0″ panel containing 32 sq. ft. of forms:

	Feet	Rate	Total	Rate	Total
2 pcs. 2″x4″-8′-0″	10.67	$.....	$.....	$ 0.150	$ 1.60
6 pcs. 2″x4″-4′-0″	16.00	.....	.....	.15	2.40
32 sq. ft. sheathing plus 20% waste	38.50	.....	.....	.12	4.62
Nails, strap iron, etc. ..		.....	.....	.50	.50
Carpenter, ¾ hr.		.....	.....	6.75	5.06
Labor, ¼ hr.		.....	.....	5.00	1.25
Cost per panel	65.17		$.....		$15.43
Cost per sq. ft.	2.04		.....		.48
Material cost per sq. ft.			.....		.28
Labor cost per sq. ft. ..			.....		.20

The actual sq. ft. cost will vary with the number of time they may be used but on straight work they should be used 6 t 7 times without difficulty. Based on using them 7 times the cos would be 5 cts. per sq. ft. for material each time used, plus cos of minor repairs, probably about 1½ to 2 cts. per sq. ft.

The cost of a similar panel 4'-0"x8'-0" in size, using ¾" "Ply form" plywood instead of 1"x6" D&M sheathing, should cos as follows:

	Feet	Rate	Total	Rate	Total
2 pcs. 2"x4"-8'-0"	10.67	$.....	$.....	$ 0.15	$ 1.60
6 pcs. 2"x4"-4'-0"	16.00	.....	.....	.15	2.40
Plyform plywood, 4'-0"x8'-0"-¾"	32.00	.....	.....	.30	9.60
Nails, strap iron, etc. .		.....	.....	.50	.50
Carpenter, ¾ hr.		.....	.....	6.75	5.06
Labor, ¼ hr.		.....	.....	5.00	1.25
Cost per panel	58.67		$.....		$20.41
Cost per sq. ft.	1.84		.....		.64
Material cost per sq. ft.					.44
Labor cost per sq. ft. ..			.....		.20

While the initial cost of the plywood panel is somewhat highe than the one using 1"x6" D&M sheathing, the plywood form wil be much stiffer and produce a better appearing wall and 10 to 1 uses may be obtained. Based on using them 13 times, the cost would be 4 cts. per sq. ft. plus 1½ to 2 cts. per sq. ft. for minor repairs

Many contractors specializing in concrete work and especiall foundations for residences, use panel forms exclusively and ge up to 50 uses from the forms with the usual amount of repairs These conditions should be given consideration when pricing an wall work using panel forms.

Symons Steel-Ply Forms*.—Symons Steel-Ply Forms are light weight panels with a rolled steel frame completely enclosing plastic coated plywood face. The plywood has a high strengt face, which is 12% stronger than standard plywood. And due t the plastic coating, effects of moisture are reduced 40%. Th welded steel frames are painted to prevent rusting and with rea sonable care should last indefinitely.

Panels are 2'-0" wide and come in lengths ranging from 3'-0 to 8'-0" high in one foot increments. Fillers are made in width 4" to 22", from 3'-0" to 8'-0" high. All steel fillers are availabl in 1", 1½", and 2" widths. The average weight of the Steel-Ply Forms is 5 pounds per square foot. Outside corners are steel angle that lock adjoining forms together. Inside corners are 6" x 6".

The side rails of the forms are rolled exclusively for Symons and have a yield strength in excess of 60,000 P.S.I. "L" shape

*Symons Mfg. Co. Des Plaines, Ill.

cross members on all forms are on one foot centers and have a yield strength in excess of 55,000 P.S.I. The frame is 2½" in width. In the Symons system, only two basic pieces are necessary for erection—the tie, and one piece connecting hardware called the Wedge-Bolt. The same Wedge-Bolt is also used for connection of any Symons accessories to the form. In erecting forms, the panel tie is placed in the dado slot between the forms.

A wedge-bolt is inserted through the adjoining forms and tie loop. A second wedge-bolt is inserted through the slot of the first, automatically tying and joining the forms in one operation. The Symons System also uses an easy, efficient method for the erection of corners, pilasters, walers, bracing, and scaffolding. Standard panel ties have 1" breakbacks; 1½" and 2" are also available with wood cones. Safe load capacity of standard panel ties is 3,000 lbs.; flat ties 3,000 lbs. and 6,000 lbs.

In stripping, panels may be quickly released from the finished wall. Wedge-bolts are easily loosened with a hammer tap, and panel ties then removed by giving tie loops a half twist, or in the case of flat ties, a vertical hammer blow.

Used panels may be rented for 22¢ per sq. ft.; minimum rental charge is for one month. New panels rent for 30¢ per sq. ft. the first month, and 22¢ the next two. Should the contractor wish to purchase the forms, the first two months rental is applied toward the final purchase price. Rentals are charged from date shipped from distribution center and stop on date shipped from job. The contractor pays transportation charges both ways.

On a foundation wall in Chicago, with 8" walls, 7'-10" high, containing 2,500 sq. ft. of wall forms, contact area, and using Symons Steel-Ply Forms*, the following labor costs were obtained:

Erecting and Bracing Panels	Hours	Rate	Total	Rate	Total
Carpenters	12	$.....	$.....	$6.75	$ 81.00
Laborers helping	18	.....	.....	5.00	90.00
Stripping, Cleaning and Oiling for Reuse					
Carpenters	3	.....	.....	6.75	20.25
Laborers helping	4.5	.....	.....	5.00	22.50
Total Cost 2,500 Sq. Ft.	37.5		$.....		$213.75
Cost Per Sq Ft.	.011				.086†

†This figure does not include rental, and is based on one time form use only. On a repeated form use basis, this figure, including rental, has been reported by many contractors as lower.

*Symons Mfg. Co. Des Plaines, Ill.

THE SYMONS* METHOD OF FIGURING CONCRETE PRESSURES

Heavy pressure in concrete is caused by one or more of the fol lowing:

1. Fast Pouring—measured vertically. Example: A 6'-0" hig wall poured in an hour at 70° temperature. The concrete pressur at the bottom will be 750 lbs. per sq. ft. or 3,000 lbs. per tie.

Ready-mix concrete is often poured at one point to wall heigl within an hour. This will create a heavy pressure at this poin Brace this point well to hold this added pressure. Be particularl careful at outside corners as ties are furthest apart there.

2. Cold or Wet Weather—Example: A four foot wall is poure in an hour at 50° temperature. The concrete pressure at the botto will be 750 lbs. per foot, or 3,000 lbs. per tie.

3. Vibration—Example: A three foot wall is poured in an hou at 50° temperature and then vibrated. The concrete pressure the bottom will be 750 lbs. per sq. ft. or 3,000 lbs. per tie.

CONCRETE PRESSURE PER SQUARE FOOT OF FORI

Rate of Pour (Feet of Height per Hour)	2′	3′	4′	5′	6′	8′	10
Maximum Pressure per Sq. Ft. at 50°....	450	600	750	900	1,050	1,350	1,6
Maximum Pressure per Sq. Ft. at 70°....	350	450	550	650	750	950	1,1

Above chart is based on hand spading. If vibrating, figure pre sure as equal to amount of one foot faster pour.

To obtain pressure per tie, multiply square feet of wall held p tie by wall pressure per square foot.

Symons Slab Shore System*.—Symons Slab Shore System is new method of flat slab forming for multi-story high rise co struction. The system utilizes standard Steel-Ply Forms, norma used for vertical wall forming, for all decking requiremen Material adaptability, ease of assembly, speed of erection a stripping are among its many advantages.

The system utilizes pre-adjusting shores, each shore capable supporting up to 60 sq. ft. Reshoring is not necessary, and t usual "forest" of shores is eliminated. Forms are set on slidi ledger angles located on both sides of patented steel stringe These ledger angles carry the forms, which enables them to stripped without reshoring. Forms are set in place without co

*Symons Mfg. Co. Des Plaines, Ill.

Typical Method of Waling and Bracing Symons Forms

necting hardware or clamping, either from below or above decl Stripping of forms shortly after concrete placement is fast an easy. The sliding ledger angles are lowered 1½" enough to perm removal of forms. Stringers and shores remain in place elimina ing any reshoring normally required. The system has a lo carpenter-laborer ratio, and quickly releases forming equipme for re-use, completing the job in less time with less material i ventory.

On a 12-story Chicago apartment house, the contractor wa able to pour about 11,000 sq. ft. of deck every four days. In Osweg New York, on a 9-story, 90,000 sq. ft. dormitory, only 15,500 s ft. of Steel-Ply Forms were required. Three laborers set mo than 3,000 sq. ft. of decking per day.

Rental for the Slab Shore System is computed on a percenta of the final purchase price.

Symons Heavy Duty Superform*.—Symons Superform is d signed expressly for large scale work where modules are typic such as dams, power plants and bridges. Frames are 4′ x 4′ wi 3″ channel cross members. End rails are 3″ angles. Frame weig is less than 9 lbs. per sq. ft. The cambered cross members a rigid corner bracing enable the Superform to sustain a high ra of concrete placement with minimum deflection. Standard fill sizes are 1′ x 4′, 2′ x 4′, 3′ x 4′, and 4′ x 2′; special fillers are ava able in any width to 4′.

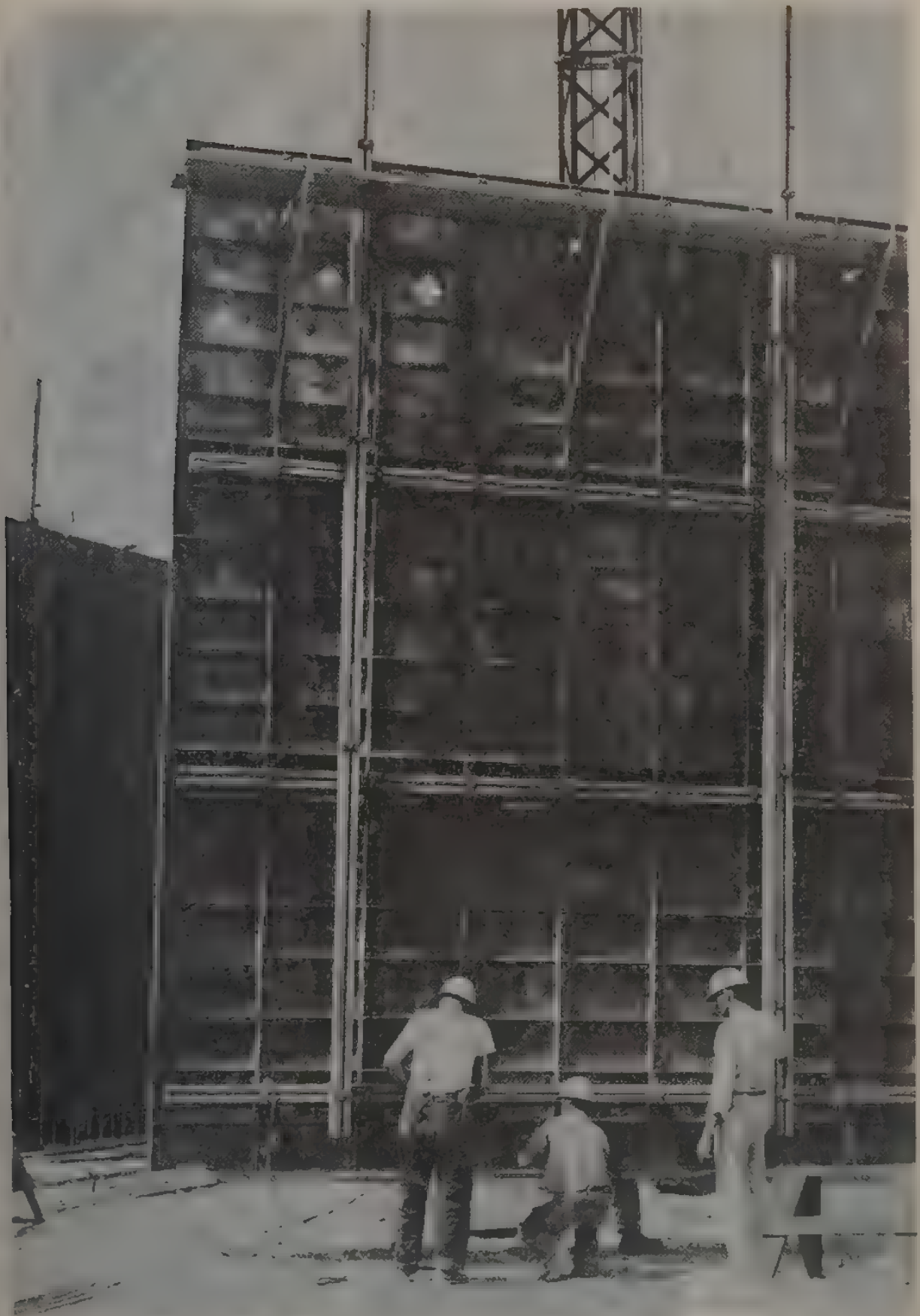
Plywood facing is purchased locally by the contractor, allo ing him to use 4′ x 8′ plywood sheets to speed assembly and m imize form joints. Plywood is quickly positioned and bolted to frames by guiding on pre-drilled frame brace holes.

Frames are assembled into gangs on an erection bed by be bolted together. Except for column forming, only two bolted c nections are necessary between adjacent side rail or end ra Spliceable steel walers and strongbacks are included in the syst and are for alignment only. Bracing is required on just one sid

Only a minimum number of ties are needed, just 4′ o.c. at panel intersection. Either she-bolts or tapered ties may be us each 25,000-lb. tie supporting 16 sq. ft. of formwork. Ties secured by cast nut, hairpin, and tie mounting bracket. In st ping, tie hardware is quickly removed, and the gang bro back with a crane.

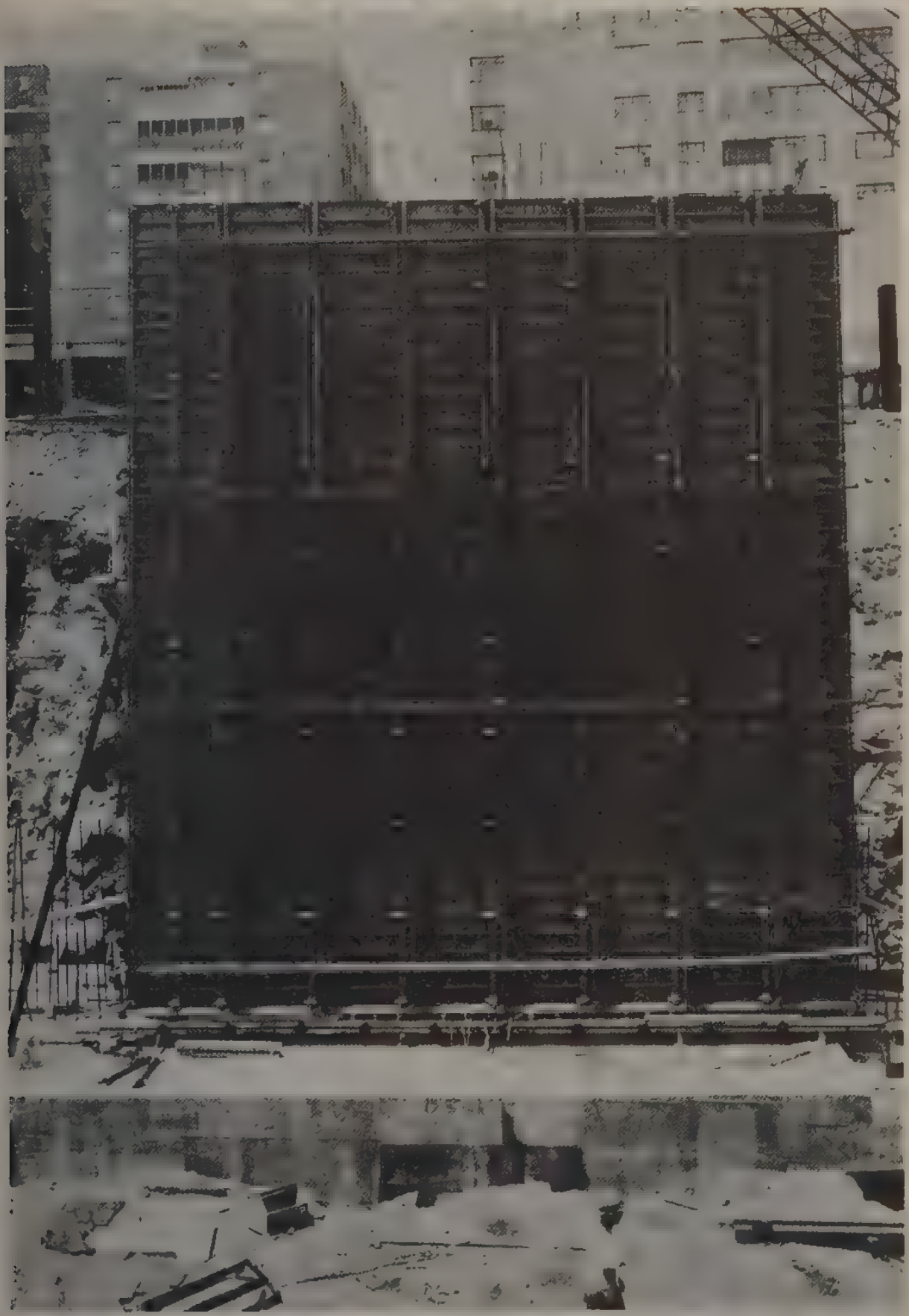
Rentals for the Superform System are computed as a percent of the final purchase price.

*Symons Mfg. Co. Des Plaines, Ill.



Ganged Symons Forms Showing Waling, Strongbacks and Scaffold Attachment

Symons Slab Shore System



Ganged Symons Superform
for 40-Foot High Wall

Uni-Form* Steel Panel Forms.—Uni-Forms are prefabricated panels consisting of a steel frame 2'x1', 2'x2', 2'x3', 2'x4', 2'x5', 2'x6', 2'x7', 2'x8', with a plywod facing. The panels are also furnished in fractional widths. The steel frame consists of a special rolled tee angle, with an equal legged tee strut to provide additional structural rigidity to the portion of the frame which acts as a plywood protector.

The plywood face is 5-ply Plyform for use in concrete forms. The plywood facing provides a convenient nailing surface. It is advisable to oil the panels after each use and with proper care Uni-Forms have been used as many as 50 times before turning the plywood.

Uni-Form panels require alignment on one side only and employ a simplified method of forming inside corners and fillers.

Panel rentals are 27 cts. per sq. ft. per month, for the first 3 months, and 21 cts. per sq. ft. per month for each month thereafter, f.o.b. factory. In many cases contractors have used a set of panels as many as 8 times per month. This results in a cost based on a rental figure of less than 4 cts. per sq. ft. of contact area. Panels can also be furnished on a sale basis or rented with an option to purchase.

On a foundation wall job for 47 houses requiring 2,350 sq. ft. of forms per house, using the 7' Uni-Form panels, the following labor costs were obtained:

Erection	Hours	Rate	Total	Rate	Total
Carpenter foreman	6	$.....	$.....	$7.00	$ 42.00
Carpenters	30	.....	.....	6.75	202.50
Labor	18	.....	.....	5.00	90.00
Stripping, Cleaning and Moving					
Carpenters	10	.....	.....	6.75	67.50
Labor	8	.....	.....	5.00	40.00
Total cost 2,350 sq. ft.	72		$.....		$442.00
Cost per sq. ft.	0.031		.....		.188

A carpenter erected and braced 78.3 sq. ft. of forms per hr. and required 0.6 hr. labor time to each hr. carpenter time. A carpenter stripped 235 sq. ft. of forms an hr. A laborer cleaned, oiled, and moved 294 sq. ft. of forms an hr.

On another foundation wall job for 50 houses, requiring 1,550 sq. ft. of forms per house (forms 2'-0"x7'-0" and 1'-0"x7'-0" sizes), the following labor costs were obtained per 100 sq. ft. of forms, contact area:

*Universal Form Clamp Co., Chicago.

Uni-Form Concrete Wall Forms

Erecting and Bracing Panels	Hours	Rate	Total	Rate	Total
Carpenter	2.6	$.....	$.....	$6.75	$17.55
Stripping Forms and Moving to Adjacent Job					
Carpenter	0.5	.....	.....	6.75	3.38
Labor	0.8	.....	.....	5.00	4.00
Oiling Panels for Each Job					
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 sq. ft.	4.4		$.....		$27.43
Cost per sq. ft.			.....		.274

A carpenter erected and braced 38.75 sq. ft. of forms per hr. A carpenter stripped 194 sq. ft. of forms per hr. A laborer oiled 194 sq. ft. of forms per hr. A laborer carried from one job to the other or loaded into trucks, 129 sq. ft. of forms per hr.

Wood Forms Built-in-Place for Concrete Foundation Walls.—Once the method of forming employed by most contractors, built-in-place wood foundation forms have been more or less relegated to the background by the more up-to-date method of using prefabricated form panels, either factory built or contractor built. However, instances may occur where built-in-

place wall forming may be the quickest, easiest or cheapest method to use so the following information is given on this type of forming.

As previously mentioned, wall form design, including both material and labor costs of constructing same, will vary with the height of the wall, temperature of the concrete and the rate at which the forms are filled. To enable the estimator to accurately design a wall form to meet almost any condition in ordinary construction work, excluding dams, spillways, tunnels and other heavy construction, the tables on the following pages give design data for safe spacing of studs, wales and ties for a number of combinations of forming materials, different methods of tying and various rates of placing concrete with their respective concrete pressures for both 50 and 70 degree concrete.

Estimating Material Requirements for Wood Forms Built-in-Place for Concrete Foundation and Retaining Walls

Assuming a wall 40′-0″ long and 6′-0″ high, using 7″ slump concrete at 50° F. and placed at the rate of 4′-0″ high per hour.

The maximum pressure on the forms would be about 750 lbs. per sq. ft. and the material required for 480 sq. ft. of forms would be as follows:

	Feet	Rate	Total	Rate	Total
Studs, 58 pcs. 2″x4″-6′-0″ (studs 17″ on centers)..	232	$.....	$.....	$0.150	$34.80
Sheathing 480 sq. ft. plus 20% waste	576	.....	.....	.120	69.12
Sills, 80 lin. ft. 2″x4″....	53	.....	.....	.150	7.95
Wales, 3 sets per side 12 pcs. 2″x4″-40′-0″	320	.....	.....	.150	48.00
Bracing and stakes, 2″x4″.	70	.....	.....	.150	10.50
Cost 480 sq. ft.	1,251	.....	$.....		$170.37
Cost per sq. ft.	2.61		.....		.355

Material not subject to reuse	Quan.	Rate	Total	Rate	Total
Nails	25 lbs.	$.....	$.....	$0.18	$ 4.50
Form ties, 22″ c.c. along wales	66	.....	.....	.10	6.60
Total Cost 480 sq. ft. ...			$.....		$11.10
Cost per sq. ft.			.....		.023

Assuming 3 uses of form lumber, .355 ÷ 3 = 11.8 cts. per use for form lumber plus 2.3 cts. per sq. ft. for nails and form ties, or a total of 14.1 cts. per sq. ft for material.

Lumber Required for Concrete Wall Forms 8′-0″ High

Based on a wall 40′-0″ long and 8′-0″ high, containing 640 sq. ft. of forms, with the concrete at 50° F. and poured into the forms at the rate of 4′-0″ per hour, resulting in a maximum pressure of about 750 lbs. per sq. ft. of the concrete on the forms, the following lumber would be required:

	Feet	Rate	Total	Rate	Total
Studs, 58 pcs. 2″x4″-8′-0″ (17″ on centers)	309	$.....	$.....	$0.15	$ 46.35
Sheathing, 640 sq. ft. plus 20% waste	768	.....	.....	.12	92.16
Sills, 80 lin. ft. 2″x4″	53	.....	.....	.15	7.95
Wales, 4 sets per side, 16 pcs. 2″x4″-40′-0″	427	.....	.....	.15	64.05
Bracing and stakes, 2″x4″	80	.....	.....	.15	12.00
Cost 640 sq. ft.	1,637		$.....		$222.51
Cost per sq. ft.	2.56		.....		.348
Material not subject to reuse:	**Quan.**	**Rate**	**Total**	**Rate**	**Total**
Nails	35 lbs.	$.....	$.....	$0.18	$ 6.30
Form ties, 22″ c.c. along wales	88	.....	.....	.10	8.80
Total cost 640 sq. ft.			$.....		$ 15.10
Cost per sq. ft.			.....		.024

Assuming 3 uses of form lumber, .348÷3=11.6 cts. per use for form lumber, plus 2.4 cts. per sq. ft. for nails and form ties, or a total of 14.0 cts. per sq. ft. for material.

Forms for Heavy Foundation or Retaining Walls.—Forms for heavy foundation or retaining walls will cost more per square foot than forms for low walls because of the additional wales, the heavier bracing and the longer and heavier tie rods or bolts necessary, due to the increased pressure of the wet concrete.

Lumber Required for Concrete Wall Forms 12′-0″ High

Based on a wall 40′-0″ long and 12′-0″ high, containing 960 sq. ft. of forms, with the concrete at 50° F. and poured into the forms at the rate of 6′-0″ per hour, resulting in a maximum pressure of about 1,050 lbs. per sq. ft. of the concrete on the forms, the following lumber would be required:

	Feet	Rate	Total	Rate	Total
Sills, 4 pcs. 2"x4"-20'-0"...	53	$.....	$.....	$0.15	$ 7.95
Studs, 66 pcs. 2"x4"-12'-0". (15" on centers).....	528	.....	.....	.15	79.20
Sheathing, 960 sq. ft. plus 20% waste 1,152		.....	.....	.12	138.24
Wales, 6 sets per side wales about 24" on centers					
24 pcs. 2"x4"-40'-0".....	640	.....	.....	.15	96.00
Bracing and stakes, 2"x4"..	98	.....	.....	.15	14.70
Cost 960 sq. ft.....2,471			$.....		$336.09
Cost per sq. ft.....	2.58		.....		.350

Material not subject to reuse:	Quan.	Rate	Total	Rate	Total
Nails	50 lbs.	$.....	$.....	$0.18	$ 9.00
Form ties (3,000 lb. safe load) 17" o.c. along wales 168		.....	.....	.105	17.64
Total cost 960 sq. ft....			$.....		$26.64
Cost per sq. ft.....			.....		.028

Assuming 3 uses of form lumber, .35÷3=11.7 cts. per use for form lumber plus 2.8 cts. per sq. ft. for nails and form ties, or a total of 14.5 cts. per sq. ft. for material.

Lumber Required for Concrete Wall Forms 16'-0" High

Based on a wall 40'-0" long and 16'-0" high, containing 1,280 sq. ft. of forms, with a maximum pressure of 750 lbs. per sq. ft. of the concrete on the forms.

	Feet	Rate	Total	Rate	Total
Sills, 4 pcs. 2"x6"-20'-0".....	80	$.....	$.....	$0.15	$ 12.00
Studs, 58 pcs. 2"x6"-16'-0" (17" on centers)	928	.....	.....	.15	139.20
Sheathing, 1,280 sq. ft. plus 20% 1,536		.....	.....	.12	184.30
Wales, 6 sets per side					
Wales, 48 pcs. 2"x6"-20'-0"	960	.....	.....	.15	144.00
Bracing and stakes.....	248	.....	.....	.15	37.20
Cost 1,280 sq. ft. forms...3,752			$.....		$516.70
Cost per sq. ft.....	2.93		.....		.40

LUMBER AND FORM TIE DATA			SAFE SPACING OF STUDS, WALES, AND FORM TIES FOR CONCRETE WALL FORMS							
LUMBER SIZES	FORM TIES		POURING TEMPERATURES	50° FAHR.						
	TYPE	SAFE LOAD	RATE OF POUR FT. OF HEIGHT PER HOUR	2 Ft.	3 Ft.	4 Ft.	5 Ft.	6 Ft.	8 Ft.	10 Ft.
			CONCRETE PRESSURE IN POUNDS PER SQ. FT. OF FORMS	450	600	750	900	1,050	1,350	1,650
1" SHEATHING 2 x 4 STUDS 2—2 x 4 WALES	ROD CLAMPS WITH 1/4" PLAIN RODS BAND CLAMPS WITH SPECIAL 1/2" x 1" GA. BAND IRON	1500 Lbs.	Stud Spacing for Safe Value of Sheathing	21"	19"					
			Wale Spacing for Safe Value of Studs	30"	28"					
			Tie Spacing for Safe Value of Ties and/or Wales	16"	13"					
1" SHEATHING 2 x 4 STUDS 2—2 x 4 WALES	SNAP TIES ROD CLAMPS WITH 3/8" PLAIN RODS	3000 Lbs.	Stud Spacing for Safe Value of Sheathing	21"	19"	17"	16"	15"	13"	12"
			Wale Spacing for Safe Value of Studs	30"	28"	26"	25"	24"	22"	20"
			Tie Spacing for Safe Value of Ties and/or Wales	32"	26"	22"	19"	17"	15"	13"
1" SHEATHING 2 x 4 STUDS 2—2 x 4 WALES	SNAP TIES 1/2" COIL TIES TILT LOCKS—3/8" COLD ROLLED RODS ROD CLAMPS—1/2" PLAIN RODS	5000 Lbs.	Stud Spacing for Safe Value of Sheathing	21"	19"	17"	16"	15"	13"	12"
			Wale Spacing for Safe Value of Studs	30"	28"	26"	25"	24"	22"	20"
			Tie Spacing for Safe Value of Ties and/or Wales	32"	29"	27"	25"	24"	23"	21"
1" SHEATHING 2 x 4 STUDS 2—2 x 6 WALES	1/2" COIL TIES TILT LOCKS WITH 3/8" COLD ROLLED TIE RODS ROD CLAMPS WITH 1/2" PLAIN RODS	5000 Lbs.	Stud Spacing for Safe Value of Sheathing	21"	19"	17"	16"	15"	13"	12"
			Wale Spacing for Safe Value of Studs	30"	28"	26"	25"	24"	22"	20"
			Tie Spacing for Safe Value of Ties and/or Wales	51"	43"	37"	32"	28"	24"	22"
1" SHEATHING 2 x 6 STUDS 2—2 x 6 WALES	1/2" COIL TIES TILT LOCKS WITH 3/8" COLD ROLLED TIE RODS ROD CLAMPS WITH 1/2" PLAIN RODS	5000 Lbs.	Stud Spacing for Safe Value of Sheathing	21"	19"	17"	16"	15"	13"	12"
			Wale Spacing for Safe Value of Studs	48"	43"	41"	39"	37"	34"	31"
			Tie Spacing for Safe Value of Ties and/or Wales	33"	28"	23"	20"	18"	16"	14"
1 1/4" SHEATHING 2 x 6 STUDS 2—2 x 6 WALES	1/2" COIL TIES TILT LOCKS WITH 3/8" COLD ROLLED TIE RODS ROD CLAMPS WITH 1/2" PLAIN RODS	5000 Lbs.	Stud Spacing for Safe Value of Sheathing	29"	27"	25"	23"	21"	19"	17"
			Wale Spacing for Safe Value of Studs	42"	36"	34"	32"	30"	28"	26"
			Tie Spacing for Safe Value of Ties and/or Wales	38"	33"	28"	25"	23"	19"	17"
1" SHEATHING 2 x 6 STUDS 2—2 x 6 WALES	3/4" COIL TIES TILT LOCKS WITH 1/2" COLD ROLLED TIE RODS ROD CLAMPS WITH 5/8" PLAIN RODS	9000 Lbs.	Stud Spacing for Safe Value of Sheathing	21"	19"	17"	16"	15"	13"	12"
			Wale Spacing for Safe Value of Studs	48"	43"	41"	39"	37"	34"	31"
			Tie Spacing for Safe Value of Ties and/or Wales	40"	37"	33"	31"	29"	28"	25"
1 1/4" SHEATHING 2 x 6 STUDS 2—2 x 6 WALES	3/4" COIL TIES TILT LOCKS WITH 1/2" COLD ROLLED TIE RODS ROD CLAMPS WITH 5/8" PLAIN RODS	9000 Lbs.	Stud Spacing for Safe Value of Sheathing	29"	27"	25"	23"	21"	19"	17"
			Wale Spacing for Safe Value of Studs	42"	36"	34"	32"	30"	28"	26"
			Tie Spacing for Safe Value of Ties and/or Wales	43"	40"	36"	34"	32"	29"	27"
1" SHEATHING 2 x 6 STUDS 2—3 x 6 WALES	3/4" COIL TIES TILT LOCKS WITH 1/2" COLD ROLLED TIE RODS ROD CLAMPS WITH 5/8" PLAIN RODS	9000 Lbs.	Stud Spacing for Safe Value of Sheathing	21"	19"	17"	16"	15"	13"	12"
			Wale Spacing for Safe Value of Studs	48"	43"	41"	39"	37"	34"	31"
			Tie Spacing for Safe Value of Ties and/or Wales	54"	50"	43"	37"	32"	28"	25"
2" SHEATHING 3 x 6 STUDS 2—3 x 6 WALES	3/4" COIL TIES TILT LOCKS WITH 1/2" COLD ROLLED TIE RODS ROD CLAMPS WITH 5/8" PLAIN RODS	9000 Lbs.	Stud Spacing for Safe Value of Sheathing	41"	36"	32"	30"	28"	24"	21"
			Wale Spacing for Safe Value of Studs	43"	40"	37"	36"	34"	31"	28"
			Tie Spacing for Safe Value of Ties and/or Wales	54"	49"	45"	40"	36"	31"	28"

The above tables are based on Hand Spading of Concrete; if mechanical vibration is used, increase estimated rate of pour by one foot per hour to determine safe spacings.

LUMBER AND FORM TIE DATA			SAFE SPACING OF STUDS, WALES, AND FORM TIES FOR CONCRETE WALL FORMS							
LUMBER SIZES	FORM TIES		POURING TEMPERATURES	70° FAHR.						
	TYPE	SAFE LOAD	RATE OF POUR FT. OF HEIGHT PER HOUR	2 Ft.	3 Ft.	4 Ft.	5 Ft.	6 Ft.	8 Ft.	10 Ft.
			CONCRETE PRESSURE IN POUNDS PER SQ. FT. OF FORMS	350	450	550	650	750	950	1,150
1" SHEATHING 2 x 4 STUDS 2—2 x 4 WALES	ROD CLAMPS WITH ¼" PLAIN RODS BAND CLAMPS WITH SPECIAL ½" x 1" GA. BAND IRON	1500 Lbs.	Stud Spacing for Safe Value of Sheathing	23"	21"					
			Wale Spacing for Safe Value of Studs	33"	30"					
			Tie Spacing for Safe Value of Ties and/or Wales	19"	16"					
1" SHEATHING 2 x 4 STUDS 2—2 x 4 WALES	SNAP TIES ROD CLAMPS WITH ⅜" PLAIN RODS	3000 Lbs.	Stud Spacing for Safe Value of Sheathing	23"	21"	20"	18"	17"	15"	14"
			Wale Spacing for Safe Value of Studs	33"	30"	29"	28"	26"	24"	22"
			Tie Spacing for Safe Value of Ties and/or Wales	36"	32"	27"	24"	22"	19"	16"
1" SHEATHING 2 x 4 STUDS 2—2 x 4 WALES	SNAP TIES ½" COIL TIES TILT LOCKS—⅜" COLD ROLLED RODS ROD CLAMPS—½" PLAIN RODS	5000 Lbs.	Stud Spacing for Safe Value of Sheathing	23"	21"	20"	18"	17"	15"	14"
			Wale Spacing for Safe Value of Studs	33"	30"	29"	28"	26"	24"	22"
			Tie Spacing for Safe Value of Ties and/or Wales	36"	33"	30"	28"	27"	25"	23"
1" SHEATHING 2 x 4 STUDS 2—2 x 6 WALES	½" COIL TIES TILT LOCKS WITH ⅜" COLD ROLLED TIE RODS ROD CLAMPS WITH ½" PLAIN RODS	[illegible] Lbs.	Stud Spacing for Safe Value of Sheathing	23"	21"	20"	18"	17"	15"	14"
			Wale Spacing for Safe Value of Studs	33"	30"	29"	28"	26"	24"	22"
			Tie Spacing for Safe Value of Ties and/or Wales	56"	51"	45"	38"	37"	32"	28"
1" SHEATHING 2 x 6 STUDS 2—2 x 6 WALES	½" COIL TIES TILT LOCKS WITH ⅜" COLD ROLLED TIE RODS ROD CLAMPS WITH ½" PLAIN RODS	5000 Lbs.	Stud Spacing for Safe Value of Sheathing	23"	21"	20"	18"	17"	15"	14"
			Wale Spacing for Safe Value of Studs	51"	48"	45"	43"	41"	38"	35"
			Tie Spacing for Safe Value of Ties and/or Wales	40"	33"	29"	26"	23"	20"	17"
1¼" SHEATHING 2 x 6 STUDS 2—2 x 6 WALES	½" COIL TIES TILT LOCKS WITH ⅜" COLD ROLLED TIE RODS ROD CLAMPS WITH ½" PLAIN RODS	5000 Lbs.	Stud Spacing for Safe Value of Sheathing	31"	29"	28"	26"	25"	22"	20"
			Wale Spacing for Safe Value of Studs	45"	42"	37"	35"	34"	31"	29"
			Tie Spacing for Safe Value of Ties and/or Wales	43"	38"	35"	31"	28"	25"	21"
1" SHEATHING 2 x 6 STUDS 2—2 x 6 WALES	¾" COIL TIES TILT LOCKS WITH ½" COLD ROLLED TIE RODS ROD CLAMPS WITH ⅝" PLAIN RODS	9000 Lbs.	Stud Spacing for Safe Value of Sheathing	23"	21"	20"	18"	17"	15"	14"
			Wale Spacing for Safe Value of Studs	51"	48"	45"	43"	41"	38"	35"
			Tie Spacing for Safe Value of Ties and/or Wales	45"	40"	38"	35"	33"	30"	27"
1¼" SHEATHING 2 x 6 STUDS 2—2 x 6 WALES	¾" COIL TIES TILT LOCKS WITH ½" COLD ROLLED TIE RODS ROD CLAMPS WITH ⅝" PLAIN RODS	9000 Lbs.	Stud Spacing for Safe Value of Sheathing	31"	29"	28"	26"	25"	23"	21"
			Wale Spacing for Safe Value of Studs	45"	42"	37"	35"	34"	31"	29"
			Tie Spacing for Safe Value of Ties and/or Wales	48"	43"	41"	38"	36"	33"	30"
1" SHEATHING 2 x 6 STUDS 2—3 x 6 WALES	¾" COIL TIES TILT LOCKS WITH ½" COLD ROLLED TIE RODS ROD CLAMPS WITH ⅝" PLAIN RODS	9000 Lbs.	Stud Spacing for Safe Value of Sheathing	23"	21"	20"	18"	17"	15"	14"
			Wale Spacing for Safe Value of Studs	51"	48"	45"	43"	41"	38"	35"
			Tie Spacing for Safe Value of Ties and/or Wales	60"	54"	51"	45"	43"	36"	32"
2" SHEATHING 3 x 6 STUDS 2—3 x 6 WALES	¾" COIL TIES TILT LOCKS WITH ½" COLD ROLLED TIE RODS ROD CLAMPS WITH ⅝" PLAIN RODS	9000 Lbs.	Stud Spacing for Safe Value of Sheathing	43"	41"	38"	36"	32"	29"	27"
			Wale Spacing for Safe Value of Studs	48"	43"	41"	38"	37"	35"	33"
			Tie Spacing for Safe Value of Ties and/or Wales	58"	54"	50"	48"	45"	39"	34"

The above tables are based on Hand Spading of Concrete. If mechanical vibration is used, increase [illegible] safe spacings

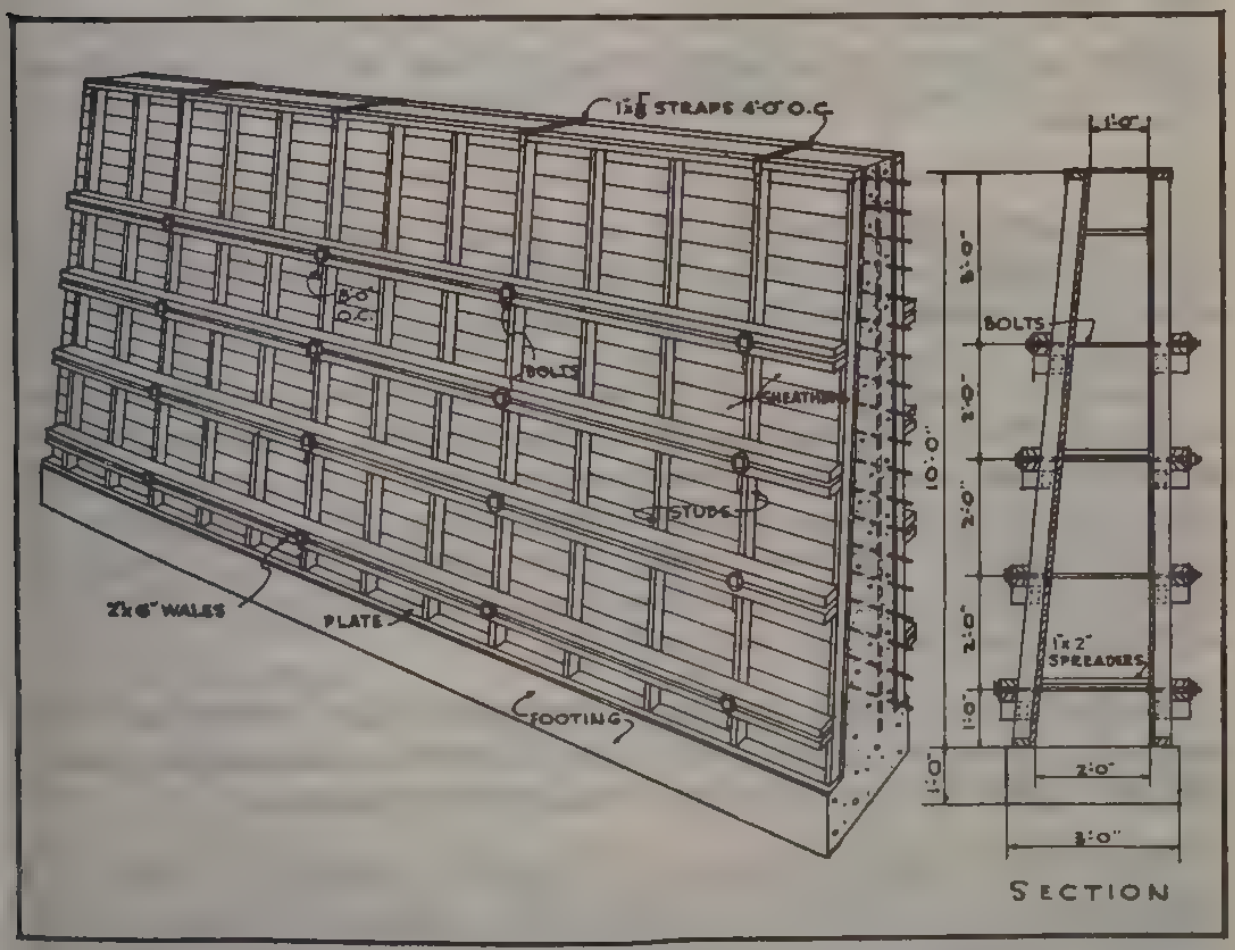
Material not subject to reuse:	Quan.	Rate	Total	Rate	Total
Nails, lbs.	60	$.....	$.....	$0.18	$ 10.80
Form ties (5,000-lb. safe load) 23" o.c.	126	.....	.....	.12	15.12
Cost 1,280 sq. ft.			$.....		$ 25.92
Cost per sq. ft.			.....		.020

Assuming 3 uses of form lumber, .404÷3=13.5 cts. per use for form lumber, plus 2.0 cts. per sq. ft. for nails and form ties, or a total of 15.5 cts. per sq. ft. for material.

When concrete walls are 16′-0″ to 20′-0″ in height, 2″x6″ studs should be used on account of the difficulty in obtaining straight 2″x4″s of that length.

Material Required for Concrete Wall Forms 18′-0″ High

Based on a wall 40′-0″ long, 18′-0″ high, containing 1,440 sq. ft. of forms, poured 6′-0″ per hour at 50° F. with a maximum pressure of 1,050 lbs. per sq. ft. of forms.



Forms for Heavy Foundation or Retaining Walls. Bottom Wale Should Not Be More Than 1′-0″ from Bottom of Wall.

	Feet	Rate	Total	Rate	Total
Bottom plates, 2 pcs. 2"x6"-40'-0"	80	$.....	$.....	$0.15	$ 12.00
Studs, 15" c.c. 64 pcs. 2"x6"-18'-0"	1,152	.....	.....	.15	172.80
Sheathing, 1,440 sq. ft. plus 20% waste	1,728	.....	.....	.12	207.36
Wales, 6 sets per side, 24 pcs. 2"x6"-40'-0"	960	.....	.....	.15	144.00
Bracing and stakes, 2"x4" and 4"x4"	328	.....	.....	.15	49.20
Cost 1,440 sq. ft. forms	4,248		$.....		$585.36
Cost per sq. ft.	2.95				.406

Material not subject to reuse:	Quan.	Rate	Total	Rate	Total
Nails, lbs.	70	$.....	$.....	$0.18	$ 12.60
Form ties (5,000 lb. safe load) 18" c.c. along wales	162	.....	.....	.12	19.44
Total cost 1,440 sq. ft.			$.....		$ 32.04
Cost per sq. ft.			.....		.022

Assuming 3 uses of form lumber, .406÷3=13.5 cts. per use for form lumber plus 2.2 cts. per sq. ft. for nails and form ties, or a total of 15.7 cts. per sq. ft. for material.

For walls higher than 20'-0", it may be necessary to use 3"x6" or 3"x8" studs, which will increase the lumber requirements accordingly, especially if forms are handled and set with a derrick.

Concrete Foundation and Retaining Walls Using Plywood Instead of Wood Sheathing.—On certain classes of concrete work where an absolutely smooth concrete surface is desired, free from board marks and the graining of the lumber, it is customary to use ¾" Plyform Plywood instead of ordinary wood sheathing. Concrete having the proper consistency and adequately vibrated results in perfectly smooth walls.

Forms of this kind are more expensive than where ordinary sheathing boards are used but they do reduce the cost of patching and rubbing the concrete to a smooth surface.

Plywood is usually furnished in sheets or panels 4'-0" wide and 8'-0" long, so the studs should be spaced 12" or 16" on centers to work out with the plywood sizes. Also when using plywood on fairly high walls, it is advisable to use 2"x6" for stud

inasmuch as these walls must be perfectly straight and 2"x6" studs will usually produce a straighter wall than 2"x4" studs.

The grain of the outside plies of the plywood should be perpendicular to the studs and information in the following tables is based on this practice. Where studs are placed parallel to the grain they must be closer together.

Material costs will be increased approximately 20 percent when plywood is used, due to closer spacing of studs and the extra cost of plywood over 1"x6" D&M sheathing.

If care is used in stripping the plywood from the wall, double the number of uses obtained from 1"x6" sheathing may be expected and the above percentage is based on this assumption.

Where walls up to 8'-0" high are required, it is advisable to use concrete forms made up into panels as described on the previous pages.

On walls over 8'-0" high panel forms may also be used by using a combination of panels, one set on top of the other. When this method is used the labor costs will be about the same as for ordinary concrete wall forms of the same height.

However, in order to make a comparison between the cost of regular forms and forms using plywood for sheathing, the following lumber will be required for a wall 40'-0" long and 12'-0" high, containing 960 sq. ft. of forms, based on a maximum pressure of 750 lbs. per sq. ft. on the forms, using plywood sheathing:

	Feet	Rate	Total	Rate	Total
Sills, 4 pcs. 2"x6"-20'-0"...	80	$.....	$.....	$0.15	$ 12.00
Studs, 62 pcs. 2"x6"-12'-0" (16" on centers)	744	.....	.....	.15	111.60
Plyform sheathing, 960 sq. ft. ¾".....	960	.....	.....	.30	288.00
Wales, 4 sets per side					
Wales, 32 pcs. 2"x6"-20'-0"	640	.....	.....	.15	96.00
Bracing and Stakes, 2"x4".	98	.....	.....	.15	14.70
Cost 960 sq. ft. forms....2,522			$.....		$522.30
Cost per sq. ft.....	2.63		.....		.544

Material not subject to reuse:	Quan.	Rate	Total	Rate	Total
Nails, lbs.	50	$.....	$.....	$0.18	$ 9.00
Form ties (3,000-lb. safe load) 17" o.c.	112	.....	.....	0.10	11.20
Cost 960 sq. ft.			$.....		$20.20
Cost per sq. ft.			.....		.021

Assuming an average of 4 uses of form lumber (6 uses of plywood and 3 uses of framing lumber) .544 : 4=13.6 cts. per use of form lumber, plus 2.1 cts. per sq. ft. for nails and form ties, or a total of 15.7 cts. per sq. ft. for material.

Lumber Required for Concrete Wall Forms 16'-0" High, Using Plywood Sheathing

Based on a wall 40'-0" long and 16'-0" high, containing 1,280 sq. ft. of forms, with a maximum pressure of 750 lbs. per sq. ft. of the concrete on the forms:

	Feet	Rate	Total	Rate	Total
Sills, 4 pcs. 2"x6"-20'-0"	80	$.....	$.....	$0.15	$ 12.00
Studs, 62 pcs. 2"x6"-16'-0" (16" on centers)	992	.....	.....	.15	148.80
Plyform sheathing, 1,280 sq. ft. ¾"	1,280	.....	.....	.30	384.00
Wales, 6 sets per side					
Wales, 48 pcs. 2"x6"-20'-0"	960	.....	.....	.15	144.00
Bracing and stakes, 2"x4" and 2"x6"	248	.....	.....	.15	37.20
Cost 1,280 sq. ft. forms	3,560		$.....		$726.00
Cost per sq. ft.	2.78		.....		.56

Material not subject to reuse:	Quan.	Rate	Total	Rate	Total
Nails, lbs.	60	$.....	$.....	$0.18	$ 10.80
Form ties (5,000-lb. safe load) 23" o.c.	126	.....	.....	0.12	15.12
Cost 1,280 sq. ft.			$.....		$ 25.92
Cost per sq. ft.			.....		.02

Assuming an average of 4 uses of form lumber (6 uses of plywood and 3 use of framing lumber) .567÷4=14.2 cts. per use for form lumber, plus 2.0 cts per sq. ft. for nails and form ties, or a total of 16.2 cts. per sq. ft. for material

Lumber Required for Concrete Wall Forms 18'-0" High, Using Plywood Sheathing

Based on a wall 40'-0" long and 18"-0" high, containing 1,440 sq. ft. of forms, with a maximum pressure of 1,050 lbs. per sq. ft. of the concrete on the forms:

	Feet	Rate	Total	Rate	Total
Sills, 4 pcs. 2"x6"-20'-0"..	80	$.....	$.....	$0.15	$ 12.00
Studs, 82 pcs. 2"x6"-18'-0" (12" on centers).....	1,476	.....	.....	.15	221.40
Plyform sheathing, 1,440 sq. ft. ¾".....	1,440	.....	.....	.30	432.00
Wales, 6 sets per side					
Wales, 48 pcs. 2"x6"-20'-0"	960	.....	.....	.15	144.00
Bracing Timbers:					
Bracing and stakes, 2"x4" and 4"x4"	328			.15	49.20
Cost 1,440 sq. ft. forms.	4,284		$.....		$858.60
Cost per sq. ft.....	2.98		.....		.596
Material not subject to reuse:	Quan.	Rate	Total	Rate	Total
Nails, lbs.	70	$.....	$.....	$0.18	$ 12.60
Form ties (5,000 lb. safe load) 18" o.c. along wales.....	162	.....	.....	.12	19.44
Total cost 1,440 sq. ft.....		.....	$.....		$ 32.04
Cost per sq. ft.....			.....		.022

Assuming an average of 4 uses of form lumber (6 uses of plywood and 3 uses of framing lumber .596÷4=14.9 cts. per use for form lumber, plus 2.2 cts. per sq. ft. for nails and form ties, or a total of 17.1 cts. per sq. ft. for material.

Cost of 100 Sq. Ft. Concrete Wall Forms 4'-0" High, Using 4'-0"x8'-0" Panel Forms

	Hours	Rate	Total	Rate	Total
100 sq. ft. wall forms....		$.....	$	$0.072*	$ 7.20*
Wales, bracing, nails, ties		.....	.....	.02*	2.00*
Carpenter	3.50	.....	.....	6.75	23.63
Labor	1.75	.....	.....	5.00	8.75
Labor stripping-cleaning..	1.75	.....	.....	5.00	8.75
Cost 100 sq. ft.....	7.00		$.....		$50.33
Cost per sq. ft.....			.....		.503
Material cost per sq. ft...			.....		.092
Labor cost per sq. ft.....			.....		.411

*Based on 7 uses of panel forms, 10 uses of wales and 5 uses of bracing.

Basis for Computing Labor Costs.—After checking the labor costs on a large number of jobs over a period of years, it has been found that a carpenter will frame and erect about 325 to 400 ft. of lumber, b.m. per 8-hr. day, and will require ⅝ to ½-hr. labor time carrying lumber, etc., to each hour carpenter time.

If there are no laborers employed on the job and all lumber is handled and carried by carpenters, a carpenter should handle, frame and erect about 225 to 275 ft. of lumber b.m. per 8-hr. day.

When removing or "stripping" concrete forms, a carpenter or laborer should remove 750 to 1,000 ft. of lumber, b.m. per 8-hr. day.

High walls necessitating work from a scaffold requires 10 to 50 per cent more time per square foot of forms because of the additional handling and hoisting of lumber, additional bracing, and the fact that the men are working on a scaffold.

The sq. ft. costs on the following pages have been computed on the above basis.

Cost of 100 Sq. Ft. of Wood Forms for Concrete Foundation and Retaining Walls

Class of Work	Height of Wall in Feet	Ft. Lbr. per Sq. Ft. of Forms	No. Sq. Ft. of Forms 8-Hr. Day	Carpenter Hours	Labor* Hours	Removing Forms	
						No. Sq. Ft. 8-Hr. Day	Labor Hours
Panel Wall Forms							
Making Only	4 to 8	2	225–250	3.5			
Erecting and Removing	3 to 4	2	250 275	3.5	1.75	450	1.75
Erecting and Removing	5 to 8	2.2	165–190	4.5	2.25	360	2.25
Foundation Wall Forms	4 to 6	2.6	190 210	4.0	2.0	360	2.25
Foundation Wall Forms	7 to 8	2.6	165–190	4.5	2.3	350	2.20
Foundation Wall Forms	9 to 10	2.6	150–160	5.3	2.5	325	2.50
Foundation Wall Forms	11 to 12	2.6	125–135	6.0	3.0	300	2.70
Foundation Wall Forms	16 to 20	3.0	95–105	8.0	4.0	250	3.20

*If Union rules do not permit laborer working with carpenter, figure labor time as additional carpenter time.

Cost of 100 Sq. Ft. Concrete Wall Forms 5′-0″ to 8′-0″ High, Using 4′-0″x8′-0″ Panel Forms

	Hours	Rate	Total	Rate	Total
100 sq. ft. wall forms.....		.....	$.....	$0.072*	$ 7.20*
Wales, bracing, nails, ties.		.....	.....	.022*	2.20*
Carpenter	4.50	.....	.....	6.75	30.38
Labor	2.25	.....	.....	5.00	11.25
Labor stripping-cleaning .	2.25	.....	.....	5.00	11.25
Cost 100 sq. ft.....	9.00		$.....		$62.28
Cost per sq. ft.....			.....		.623
Material cost per sq. ft...			.....		.094
Labor cost per sq. ft.....			.....		.529

*Based on 7 uses of panel forms, 10 uses of wales and 5 uses of bracing.

When foundation walls rest directly on the earth without a concrete footing, mud sills of 2″ or 3″ plank are usually employed to serve as layout lines and supports for the wall panel forms required. This will increase the cost of 4′-0″ high panel wall forms about 10 percent for both material and labor. Similarly, 8′-0″ high wall forms should be increased about 5 percent.

Cost of 100 Sq. Ft. Built in Place Concrete Wall Forms 4′-0″ to 6′-0″ High, Requiring 2.6 Ft. of Lumber, B.M. Per Sq. Ft. of Forms

	Hours	Rate	Total	Rate	Total
140 ft. framing lumber....		$.....	$.....	$0.051*	$ 7.14*
120 ft. sheathing.....		.....	.....	.042*	5.04*
Nails, ties, etc.....		.....	.....	.021	2.10
Carpenter 4.0		.....	.....	6.75	27.00
Labor 2.0		.....	.....	5.00	10.00
Labor stripping-cleaning.2.25		.....	.....	5.00	11.25
Cost 100 sq. ft.....8.25			$.....		$62.53
Cost per sq. ft.....					.625
Material cost per sq. ft. ..			.....		.143
Labor cost per sq. ft.....			.....		.482

Cost of 100 Sq. Ft. Built-in-Place Concrete Wall Forms 8′-0″ High, Requiring 2.6 Ft. of Lumber, B.M. Per Sq. Ft. of Forms

	Hours	Rate	Total	Rate	Total
140 ft. framing lumber..		$.....	$.....	$0.051*	$ 7.14*
120 ft. sheathing.....		.....	.....	.042*	5.04*
Nails, ties, etc.....		.....	.....	.022	2.20*
Carpenter, ...	4.50	.....	.....	6.75	30.38
Labor helping	2.25	.....	.....	5.00	11.25
Labor stripping-cleaning	2.25	.....	.....	5.00	11.25
Cost 100 sq. ft.....	9.00		$.....		$67.26
Cost per sq. ft.....			.....		.673
Material cost per sq. ft...			.....		.144
Labor cost per sq. ft.....			.....		.529

*Based on 3 uses of lumber.

Cost of 100 Sq. Ft. Built-in-Place Concrete Wall Forms 10′-0″ High, Requiring 2.6 Ft. of Lumber, B.M. Per Sq. Ft. of Forms

	Hours	Rate	Total	Rate	Total
140 ft. framing lumber...		$.....	$.....	$0.051*	$ 7.14*
120 ft. sheathing.....		.....	.....	.042*	5.04*
Nails, ties, etc.....		.....	.....	.023	2.30
Carpenter	5.50	.....	.....	6.75	37.13
Labor helping	2.75	.....	.....	5.00	13.75
Labor stripping-cleaning	2.50	.....	.....	5.00	12.50
Cost 100 sq. ft.....	10.75		$.....		$77.86
Cost per sq. ft.....			.....		.779
Material cost per sq. ft...			.....		.145
Labor cost per sq. ft.....			.....		.634

Cost of 100 Sq. Ft. Built-in-Place Concrete Wall Forms 12′-0″ High, Requiring 2.6 Ft. of Lumber, B.M. Per Sq. Ft. of Forms

	Hours	Rate	Total	Rate	Total
140 ft. framing lumber...		$.....	$.....	$0.051*	$ 7.14*
120 ft. sheathing.....		.....	.....	.042*	5.04*
Nails, ties, etc.....		.....	.....	.025	2.50
Carpenter	6.00	.....	.....	6.75	40.50
Labor helping	3.00	.....	.....	5.00	15.00
Labor stripping-cleaning	2.75	.....	.....	5.00	13.75
Cost 100 sq. ft.....	11.75		$.....		$83.93
Cost per sq. ft.....			.....		.839
Material cost per sq. ft...			.....		.147
Labor cost per sq. ft.....			.....		.692

Cost of 100 Sq. Ft. Built-in-Place Concrete Wall Forms 16′-0″ to 20′-0″ High, Requiring 3 Ft. of Lumber, B.M. Per Sq. Ft. of Forms

	Hours	Rate	Total	Rate	Total
180 ft. framing lumber...		$.....	$.....	$0.051*	$ 9.18*
120 ft. sheathing.....		.....	.....	.042*	5.04*
Nails, ties etc.....		.....	.....	.021	2.10
Carpenter	8.00	.....	.....	6.75	54.00
Labor helping	4.00	.....	.....	5.00	20.00
Labor stripping-cleaning	3.25	.....	.....	5.00	16.25
Cost 100 sq. ft.....	15.25		$.....		$106.57
Cost per sq. ft.....			.....		1.06
Material cost per sq. ft...			.....		.16
Labor cost per sq. ft.....			.....		.90

*Based on 3 uses of lumber.

Labor on Concrete Wall Forms Using Plywood Sheathing.—The labor cost of erecting and removing concrete wall forms using plywood sheathing will run practically the same as for other types of wall forms. While there is less nailing and consequently less labor than when applying ¾" sheathing, the plywood must be oiled or receive a coating to prevent the grain from raising and care must be used in removing the plywood sheathing when removing the forms, consequently about the only difference in cost of forms is the additional cost of plywood sheathing and form coating. Plywood sheathing requires closer spacing of studs and the same spacing of wales, ties and the same amount of bracing as ¾" sheathing.

Cost of 100 Sq. Ft. Concrete Wall Forms 4'-0" High, Using 4'-0" x 8'-0" Plyform Panel Forms

	Hours	Rate	Total	Rate	Total
100 sq. ft. wall forms....		$.....	$.....	$0.061*	$ 6.10*
Wales, bracing, nails, ties		.....	.....	.020*	2.00*
Form coating		.....	.....	.011	1.10
Carpenter	3.50	.....	.....	6.75	23.63
Labor	1.75	.....	.....	5.00	8.75
Labor stripping-cleaning	1.75	.....	.....	5.00	8.75
Cost per 100 sq. ft.....	7.00		$.....		$50.33
Cost per sq. ft.....			.....		.503
Material cost per sq. ft...			.....		.092
Labor cost per sq. ft....			.....		.411

Cost of 100 Sq. Ft. Concrete Wall Forms 8'-0" High, Using 4'-0" x 8'-0" Plyform Panel Forms

	Hours	Rate	Total	Rate	Total
100 sq. ft. forms.....		$.....	$.....	$0.061*	$ 6.10*
Wales, bracing, nails, ties		.....	.....	.022*	2.20*
Form coating		.....	.....	.011	1.10
Carpenter	4.50	.....	.....	6.75	30.38
Labor	2.25	.....	.....	5.00	11.25
Labor stripping-cleaning	2.25	.....	.....	5.00	11.25
Cost per 100 sq. ft.....	9.00	.....	$.....		$62.28
Cost per sq. ft.....			.....		.623
Material cost per sq. ft...			.....		.094
Labor cost per sq. ft.....			.....		.529

* Based on 13 uses of Plyform panel forms, 10 uses of wales and 5 uses of bracing.

Cost of 100 Sq. Ft. Concrete Wall Forms 12′-0″ High, Using 4′-0″ x 8′-0″ Plyform Panel Forms

	Hours	Rate	Total	Rate	Total
100 sq. ft. wall forms...		$.....	$.....	$0.061*	$ 6.10*
Wales, 2″x4″ (10 uses) 45-ft.....		.....	.....	.015	.68
Braces, stakes, etc. (5 uses) 12-ft.....		.....	.....	.030	.36
Nails, form ties, etc.....		.....	.....	.014	1.40
Form coating		.....	.....	.011	1.10
Carpenter	5.50	.....	.....	6.75	37.13
Labor	2.75	.....	.....	5.00	13.75
Labor stripping-cleaning	2.75	.....	.....	5.00	13.75
Cost 100 sq. ft.....	11.00	.....	$.....		$74.27
Cost per sq. ft.			.....		.743
Material cost per sq. ft...			.....		.097
Labor cost per sq. ft....			.....		.646

Cost of 100 Sq. Ft Concrete Wall Forms 16′-0″ High, Using 4′-0″ x 8′-0″ Plyform Panel Forms

	Hours	Rate	Total	Rate	Total
100 sq. ft. wall forms....		$.....	$.....	$0.061*	$ 6.10*
Wales, 2″x4″ (10 uses) 50-ft.		.....	.....	.015	.75
Braces, stakes, etc. (5 uses) 12-ft.....		.....	.....	.030	.36
Nails, form ties, etc.....		.....	.....	.014	1.40
Form coating		.....	.....	.011	1.10
Carpenter	6.75	.....	.....	6.75	45.56
Labor	3.50	.....	.....	5.00	17.50
Labor stripping-cleaning	2.75	.....	.....	5.00	13.75
Cost 100 sq. ft.....	13.00		$.....		$86.52
Cost per sq. ft.....		.....	.....		.865
Material cost per sq. ft...			.....		.097
Labor cost per sq. ft.....			.....		.768

* Based on 13 uses of Plyform panel forms, 10 or 13 uses of wales and 5 uses of bracing.

Cost of 100 Sq. Ft. Built-in-Place Concrete Wall Forms 12′-0″ High, Using Plywood Sheathing

	Hours	Rate	Total	Rate	Total
160 ft. lumber.....		$.....	$.....	$0.051*	$ 8.61*
100 sq. ft. ¾″ Plyform		.....	.....	.05*	5.00*
Nails, ties, form coating.		.....	.....	.033	3.30
Carpenter	6.00	.....	.....	6.75	40.50
Labor helping	3.00	.....	.....	5.00	15.00
Labor stripping-cleaning	2.75	.....	.....	5.00	13.75
Cost per 100 sq. ft. ...	11.75		$.....		$ 86.16
Cost per sq. ft.....			.....		.862
Material cost per sq. ft...			.....		.169
Labor cost per sq. ft.....			.....		.693

Cost of 100 Sq. Ft. Built-in-Place Concrete Wall Forms 16′-0″ to 20′-0″ High, Using Plywood Sheathing

	Hours	Rate	Total	Rate	Total
198 ft. lumber.....		$.....	$.....	$0.051*	$ 10.10*
100 sq. ft. ¾″ Plyform		.....	.....	.05*	5.00*
Nails, ties, form coating		.....	.....	.033	3.30
Carpenter	8.00	.....	.....	6.75	54.00
Labor helping	4.00	.....	.....	5.00	20.00
Labor stripping-cleaning	3.25	.....	.....	5.00	16.25
Cost per 100 sq. ft.....	15.25		$.....		$108.65
Cost per sq. ft.....			$.....		1.087
Material cost per sq. ft...			.....		.184
Labor cost per sq. ft.....			.....		.903

Pilasters.—Walls which are widened for short intervals and then return to their former width are known as pilasters.

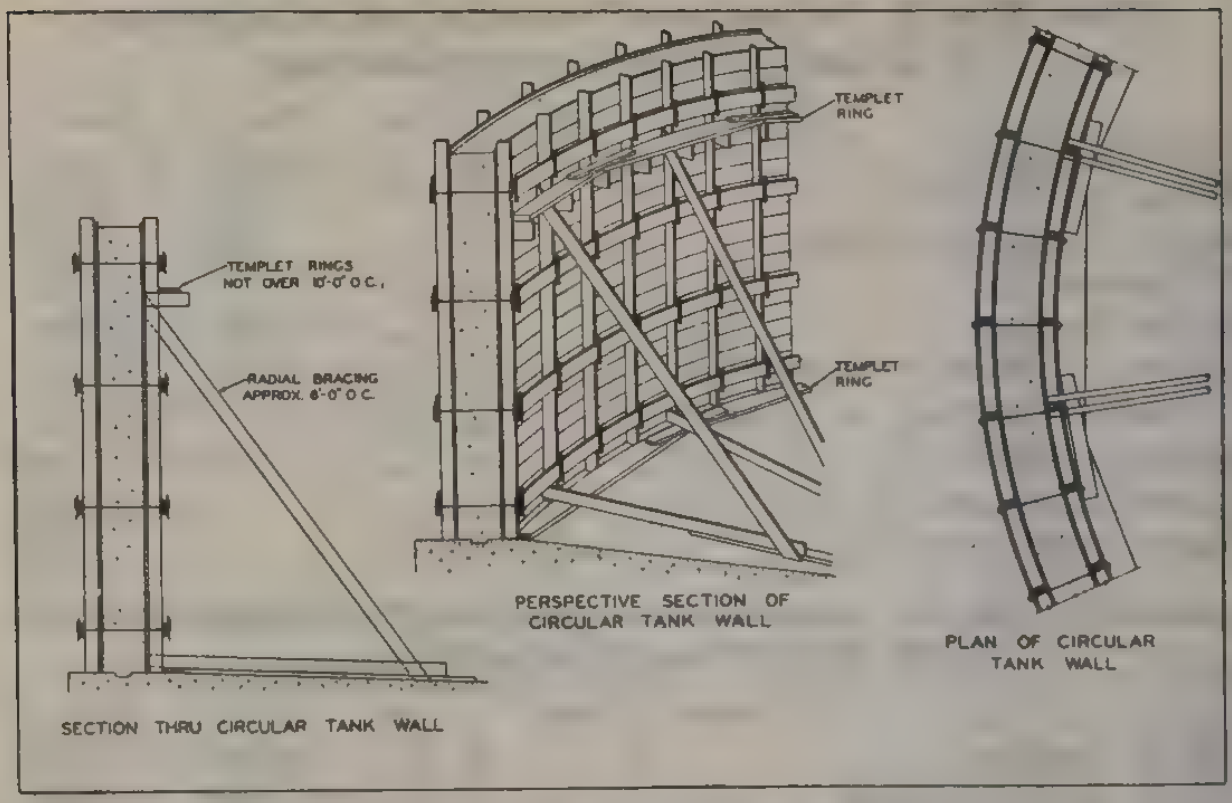
The cost of forming the face and sides of pilasters runs from 25 to 50 percent more than plain wall forms for both material and labor.

Radial Wall Forms.—Wall forms which are built to radii or other curves require closer stud spacing, more bracing and more labor laying out than straight wall forms.

Formwork for radial walls will cost from 50 to 100 percent more than forms for straight walls.

Forming Openings in Concrete Walls.—Openings in concrete walls for doors, windows, louvers, etc., are formed by placing bulkheads in the wall forms, usually consisting of 2″ lumber, accurately located to form the sills, jambs and heads of the open-

*Panel forms based on 13 uses of panels. Built-in-place forms based on 6 uses of Plyform and 3 uses of framing lumber.


TEMPLET RINGS NOT OVER 10'-0" O.C.
RADIAL BRACING APPROX. 6'-0" O.C.
SECTION THRU CIRCULAR TANK WALL
TEMPLET RING
TEMPLET RING
PERSPECTIVE SECTION OF CIRCULAR TANK WALL
PLAN OF CIRCULAR TANK WALL

Method of Forming for Radial Concrete Walls.

ings required. These forms usually require from 2¼ to 3 ft. of lumber, b.m. per sq. ft. of contact area, depending upon the size of the opening.

The following is an itemized cost of boxed opening forms, based on 4'-0"x4'-0" openings in a 1'-0" wall requiring 2½ ft. of lumber, b.m. per sq. of contact area.

Cost of 100 Sq. Ft. of Boxed Opening Forms

	Hours	Rate	Total	Rate	Total
250 ft lumber, b.m.					
(3 uses)		$.....	$.....	$0.051	$ 12.75
Nails, etc.		.....	.....	.55	.55
Carpenter, setting forms.	8.50	.....	.....	6.75	57.38
Labor helping	4.25	.....	.....	5.00	21.25
Labor stripping forms...	2.75	.....	.....	5.00	13.75
Cost 100 sq. ft.....	15.50		$.....		$105.68
Cost per sq. ft.....			.....		1.057
Material cost per sq. ft...			.....		.133
Labor cost per sq ft.....			.....		.924

Forming Setbacks in Concrete Walls.—When concrete foundation walls extend some height above ground level, it is often required that the portion above grade be faced with masonry This necessitates the portion above grade being reduced in width suffi-

cient to accommodate the facing material.

This reduction in width is accomplished by placing a "setback" form in the regular wall forms.

Setback forms are usually made up of 2" framing lumber faced with 1" sheathing, constructed on the ground in sections and set in place in the wall forms.

Setback forms usually require 1¾ to 2¼ ft. of lumber, b.m. per sq. ft. of contact area, depending mainly upon the width of the setback.

The following is an itemized cost of 100 sq. ft. of setback forms requiring 2 ft. of lumber, b.m. per sq. ft. of contact area:

	Hours	Rate	Total	Rate	Total
200 ft. lumber, b.m. (3 uses)		$.....	$.....	$0.051	$10.20
Nails, etc.		.....	.....	.55	.55
Making and Setting in Place					
Carpenter	7.50	.....	.....	6.75	50.63
Labor helping	3.75	.....	.....	5.00	18.75
Labor stripping	1.75	.....	.....	5.00	8.75
Cost 100 sq. ft.	13.00		$.....		$88.88
Cost per sq. ft.			.....		.889
Material cost per sq. ft.			.....		.108
Labor cost per sq. ft.			.....		.781

Forming Continuous Corbels on Concrete Walls.—When an intermediate support on a wall face is required to provide bearing for masonry, slabs or future construction and reducing the wall thickness is prohibited by the design, continuous corbels are commonly used.

Continuous corbels are usually formed of 2" framing lumber, faced with 1" sheathing and requires from 3½ to 4 ft. of lumber, b.m. per sq. ft. of contact area.

The following is an itemized cost of 100 sq. ft. of continuous corbel forms:

	Hours	Rate	Total	Rate	Total
400 ft. lumber, b.m. (3 uses)		$.....	$.....	$0.051	$ 20.40
Nails, etc.		.....	.....	1.10	1.10
Carpenter	12.0	.....	.....	6.75	81.00
Labor helping	6.0	.....	.....	5.00	30.00
Labor stripping forms	2.5	.....	.....	5.00	12.50
Cost 100 sq. ft.	20.5		$.....		$145.00
Cost per sq. ft.			.....		1.45
Material cost per sq. ft.			.....		.215
Labor cost per sq. ft.			.....		1.235

Form Coating

For clean, easy stripping of forms and to prolong the life of form facings, the contact surface of all forms should receive a coating which will prevent concrete from bonding to the form face.

The old method of brushing or spraying form faces with paraffin oil is still used by a large number of contractors and gives adequate results for the average job, such as foundation walls, unexposed columns, beams and slabs, etc.

Forms should always be coated before erection, but where this is impracticable, such as for built-in-place wall forms, pan and joist forms for combination slabs, etc., oiling should be done in advance of setting reinforcing steel and care should be taken not to get any oil on concrete, masonry or steel bearing surfaces.

Paraffin oil costs about 50 cts. per gallon in drum lots and one gallon will cover approximately 250 sq. ft. of form surface.

On large areas, such as flat slab decks, a laborer can coat 400 to 500 sq. ft. of surface per hour, but production is considerably less when coating forms for columns, beams, combination slabs, etc. A fair overall average for coating forms with paraffin oil is about 150 sq. ft. per hour.

For better class work, when using plywood, plastic-coated plywood or lined forms, where smooth concrete surfaces are required, there are numerous patented coatings and lacquers available for this purpose. While the initial cost of these coatings is much higher than paraffin oil, better results are obtained and the forms may be used 5 to 10 times without recoating, depending on the care used in applying the coating and in handling the forms when erecting or stripping.

Prices for these coating materials vary from $1.75 to $5.00 per gallon, but coverage and durability also vary. Some coatings require special thinners before application while others can be thinned with comparatively inexpensive mineral spirits. Most manufacturers claim 10 to 15 uses of forms before requiring recoating but in actual practice 5 to 6 uses is about the limit.

Application may be either by brushing, spraying or dipping and a man can coat about 100 sq. ft. of form surface per hour. Assuming 5 uses of forms before recoating is required, a fair average cost for material and labor coating forms is about 1 ct. per sq. ft. of form surface.

Formfilm*—Formfilm is a quick-drying plastic type plywood form coating with a high nitro-cellulose content. It is completely water-repellent, resistant to abrasion, and impervious to the alkaline action of concrete. It is recommended for use on untreated

*W. R. Grace Co. A. C. Horn Products.

plywood forms to produce smooth concrete surfaces free from grain markings. It is not intended for use on metal or plastic forms.

Formfilm must be applied to concrete forms which are free from oil, grease, dirt or foreign matter. It may be applied by brush, spray, roller, squeegee or dipping. Formfilm is not ready mixed because job temperatures vary widely and affect the viscosity. It is usually thinned with Formfilm Thinner to the proper working consistency.

Covering capacity: dipping and brushing, approximately 200 sq. ft. per gal. In 55-gal. drums, Formfilm costs approximately $5.00 per gal. and thinner, about $3.00 per gal.

REINFORCING STEEL

Reinforcing steel is estimated by the pound or ton (2,000 lbs.), based on the weight of the steel required in the footings or walls. Obtain the number of pieces and lengths of each size bar required and multiply this by the weight per lin. ft. The result is the weight of the reinforcing bars required for the job.

Example: Assume the retaining wall illustrated on previous pages is reinforced with #5 round bars spaced 6″ on centers both vertically and horizontally. The wall is 40′-0″ long and 15′-0″ high and with bars spaced 6″ on centers it will require the following:

80 #5 bars 15′-0″ long=1,200 lin. ft. @ 1.043 lbs.=1,252 lbs.
30 #5 bars 40′-0″ long=1,200 lin. ft. @ 1.043 lbs.=1,252 lbs.
Total weight of steel required 2,504 lbs.

If reinforcing steel is worth $13.00 per 100 lbs. or $0.13 per lb. 2,504x$0.13=$325.52, the cost of the steel.

Mesh reinforcing is also commonly used for work of this kind and the quantities should be obtained in sq. ft. Example: Wall 40′-0″x15′-0″=600 sq. ft. plus 5% for waste or laps, making a total of 630 sq. ft. of mesh required. The price of mesh reinforcing is based on a certain price per sq. ft. depending upon the weight.

Sizes and Weights of Reinforcing Bars and Mesh.—See Tables of Weights under "Reinforced Concrete."

Unloading Reinforcing Bars from Cars or Trucks.—If steel can be unloaded direct from cars or trucks, without sorting or carrying to stock piles, a laborer will unload 4 to 5 tons per 8-hr. day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Labor	1.75	$.....	$.....	$5.00	$8.75

If it is necessary to carry the bars up to 50 ft. sort and place in stock piles, figure 2½ to 3 tons per 8-hr. day per man, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Labor	3.0	$.....	$.....	$5.00	$15.00

Labor Placing Reinforcing Steel.—This cost is subject to considerable variation, due to the class of work, size of bars and the workmen employed on the job.

In many of the larger cities there are concerns making a specialty of setting reinforcing steel. These men become very adept at this work and under favorable conditions can place steel for 25% less than the iron worker who has just an occasional job of this kind. For this reason costs are given both ways and the estimator should use his own judgement as to the class of workmen available.

When the setting of reinforcing steel is sublet to a firm or individual specializing in reinforcing steel setting only, it may often be sublet at $70.00 to $100.00 per ton, including unloading steel on the job and placing ready to receive concrete.

The size of the bars also affects the labor costs, as it is cheaper to place a ton of heavy bars (¾" and larger), than small bars (⅝" and smaller). The heavier the bars, the less the labor cost per ton.

Where the reinforcing bars are placed loose in footings and piers, without tying in place, a man should carry and place 1,300 to 1,500 lbs. per 8-hr. day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Steel setter	11.5	$.....	$.....	$7.10	$81.65

An experienced reinforcing steel setter should place 1,800 to 2,000 lbs. per 8-hr. day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Steel setter	8.5	$.....	$.....	$7.10	$60.35

In retaining walls, cantilever girder frames, foundation walls, etc., where it is necessary to wire all bars in place, both vertically and horizontally, a man should place 650 to 850 lbs. per 8-hr. day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Steel setter	20.7	$.....	$.....	$7.10	$146.97

An experienced reinforcing steel setter should place 900 to 1,100 lbs. per 8-hr. day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Steel setter	16.1	$.....	$.....	$7.10	$114.31

Labor Placing Mesh Reinforcing.—When mesh reinforcing is used, furnished in sheets or rolls, a man should place 700 to 800 sq. ft. in walls per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Steel setter	1.0	$.....	$.....	$7.10	$7.10
Cost per sq. ft.			$.....		.071

Weights of Miscellaneous Building Materials

Weight of Cement, Sand, Gravel, Crushed Stone, Concrete, Etc.

The following table gives the approximate weights of cement, concrete and concrete aggregates, and will assist the estimator in figuring freight or cartage or when purchasing materials by weight:

	Weight Lbs. Per Cu. Yd.
Bank sand	2,500
Torpedo sand	2,700
Crushed stone	2,500
Crushed stone screenings	2,500
Gravel	2,700
Roofing Gravel	2,700

Cement weighs 376 lbs. per bbl.
(1-sack weighs 94 lbs. and bulks 1-cu. ft.)

Cinder concrete	Wt. per cu. ft.	112
Concrete of gravel, limestone, sandstone, trap, etc.	Wt. per cu. ft.	150

Quantity of Pit Run Sand and Gravel Required for One Cubic Yard of Concrete.—Pit run sand and gravel is not recommended for concrete work where strength is a factor because it is impossible to grade the aggregate. There is either too much gravel and too little sand or too little gravel and too much sand, usually the latter, to make a dependable concrete.

An aggregate containing approximately 50 percent sand and 50 per cent gravel (providing it does not contain any humic acid), may be considered acceptable aggregate and the strength will probably be only ten percent less than when using aggregates furnished by washing and grading plants.

It ordinarily requires about 1.25 cu. yds. per cu. yd. of concrete, depending upon the coarseness of the sand.

Cost of One Cu. Yd. of Concrete Mixed in the Proportions of 1:4 Using Pit Run Sand and Gravel

	Rate	Total	Rate	Total
8 sacks portland cement	$.....	$.....	$1.80	$14.40
1.25 cu. yds. sand-gravel	.....	.....	3.25	4.06
Cost per cu. yd.		$.....		$18.46

Quantity of Concrete Required Per Lin. Ft. and Per 100 Lin. Ft. of Footings

Size of Footing Inches	Lin. Ft. Forms Req'd per Lin. Ft. Ftgs.	Sq. Ft. Forms Req'd per Lin. Ft. Ftgs.	Cu. Ft. Conc. Req'd per Lin. Ft. Ftgs.	Lin. Ft. Forms Req'd per 100 Lin. Ft. Ftgs.	Sq. Ft. Forms Req'd per 100 Lin. Ft. Ftgs.	Cu. Ft. Conc. Req'd per 100 Lin. Ft. Ftgs.
6x 8	2	1	0.33	200	100	33.33
6x 9	2	1	0.375	200	100	37.50
6x10	2	1	0.417	200	100	41.67
6x12	2	1	0.50	200	100	50.00
8x 8	2	1.33	0.445	200	133	44.50
8x10	2	1.33	0.556	200	133	55.56
8x12	2	1.33	0.667	200	133	66.67
8x14	2	1.33	0.778	200	133	77.78
8x16	2	1.33	0.889	200	133	88.89
8x18	2	1.33	1.000	200	133	100.00
10x10	2	1.67	0.695	200	167	69.45
10x12	2	1.67	0.833	200	167	83.33
10x14	2	1.67	0.972	200	167	97.22
10x16	2	1.67	1.111	200	167	111.11
10x18	2	1.67	1.25	200	167	125.00
10x20	2	1.67	1.39	200	167	138.89
12x12	2	2	1.000	200	200	100.00
12x14	2	2	1.167	200	200	116.67
12x16	2	2	1.333	200	200	133.33
12x18	2	2	1.5	200	200	150.00
12x20	2	2	1.667	200	200	166.67
12x22	2	2	1.833	200	200	183.33
12x24	2	2	2.000	200	200	200.00

Quantity of Forms and Concrete Required Per 100 Sq. Ft. of Wall

The sq. ft. cost of forms will depend upon height and thickness of wall. The labor cost of mixing and depositing concrete and the cost of concrete aggregate will vary with the methods used and the mixture of the concrete, viz., 1 :2.5 :3.5, 1 :2 :4, 1 :3 :5, etc.

Thickness of Wall in Inches	No. Sq. Ft. Forms Required	No. Cu. Ft. Concrete Required	No. Cu. Yds. Concrete Required	Thickness of Wall in Inches	No. Sq. Ft. Forms Required	No. Cu. Ft. Concrete Required	No. Cu. Yds. Concrete Required
4	200	33.3	1.24	14	200	116.67	4.32
5	200	41.7	1.54	15	200	125.	4.63
6	200	50.	1.85	16	200	133.33	4.94
7	200	58.3	2.16	17	200	141.7	5.25
8	200	66.7	2.47	18	200	150.	5.56
9	200	75.	2.78	19	200	158.3	5.86
10	200	83.3	3.09	20	200	166.7	6.17
11	200	91.7	3.4	21	200	175.	6.48
12	200	100	3.7	22	200	183.3	6.79
13	200	108.3	4.01	23	200	191.7	7.1
				24	200	200	7.41

Cost of One Cu. Yd. of Concrete Mixed in the Proportions of 1:5 Using Pit Run Sand and Gravel

	Rate	Total	Rate	Total
6.5 sacks portland cement.....	$.....	$.....	$1.80	$11.70
1.25 cu. yds. sand-gravel.....	.....	.....	3.25	4.06
Cost per cu. yd.		$.....		$15.76

CONCRETE

Concrete should be estimated by the cu. ft. or cu. yd. containing 27 cu. ft. The cu. yd. is the most convenient unit to use because practically all published tables giving quantities of cement, sand, gravel or crushed stone are based on the cu. yd. of concrete; it is also a convenient unit to use when estimating labor costs.

It was formerly the practice to specify concrete mixtures as so many volumes of fine and coarse aggregate to each volume of cement, as for example 1 :1 :2, 1 :1.5 :3, 1 :2 :4, 1 :3 :5, etc. The condition of the aggregate when measured was not specified, nor were the consistency of the concrete or the water content.

As used on the job, sand nearly always contains some surface moisture, usually around 4 or 5 percent by weight of the sand, although it may be considerably more just after rain or if the sand is used soon after washing it. The moisture causes the sand to bulk up in volume, the amount of bulking depending on the amount of moisture and the grading. This bulking which may be 20 to 30 percent or more, reduces the true volume of surface dry sand in a given volume of damp sand. For example, if a 1 :2 :4 mix is specified and 2 volumes of damp sand are measured, the volume of sand on a surface dry basis would be less. Suppose the sand is bulked 25 percent due to the moisture. Then the volume of dry sand in each cubic foot of damp sand will be 100 divided by 125, or 0.8 cu. ft. and 2 cu. ft. of damp sand would give us 2x0.8 or 1.6 cu. ft. dry sand.

The coarse aggregate carries very little surface moisture and the moisture has little effect on the volume. The result was that undersanded mixes were often used. In the above example the 1 :2 :4 mix if based on damp materials would actually be a 1 :1.6 :4 mixture of surface dry materials. The amount of sand in this case would be less than 29 percent of the total volume of aggregate. For average mixtures 35 to 45 percent is usually desirable for good workability when concrete is placed by hand.

To correct for the bulking in the above example the amount of damp sand should be increased to 1.25x2 or 2.5 cu. ft. and the

mix would then be 1 :2.5 :4 based on damp materials as measured in the field.

As a result of the increased knowledge that has been made available, other methods of specifying concrete have been adopted, such as a mix by weight, a minimum cement factor, a maximum water content or the strength at a given age, or a combination of these.

The Importance of Mixing Water.—The hardening of concrete mixtures is brought about by chemical reactions between cement and water, the aggregates (sand, gravel, stone, etc.) being inactive ingredients used as fillers. So long as workable mixtures are used, the less water there is in the mix, the stronger, more watertight and more durable will be the concrete. Excess mixing water dilutes the paste made by the cement and water and makes weaker, more porous concrete. For any set of conditions of mixing, placing and curing and for given materials there is a definite relation between the strength of the concrete and the amount of water used in mixing. This relation can be determined by test and a water-cement ratio-strength curve can be developed representing the actual results on a specific job. If laboratory test data or experience records for this relationship cannot be obtained because of time limitations, the necessary water-cement ratio may be estimated from Fig. 1; the lower edge of the applicable strength band curve should be used. A large majority of the results of strength tests made by many laboratories using a variety of materials falls within the strength band curves.

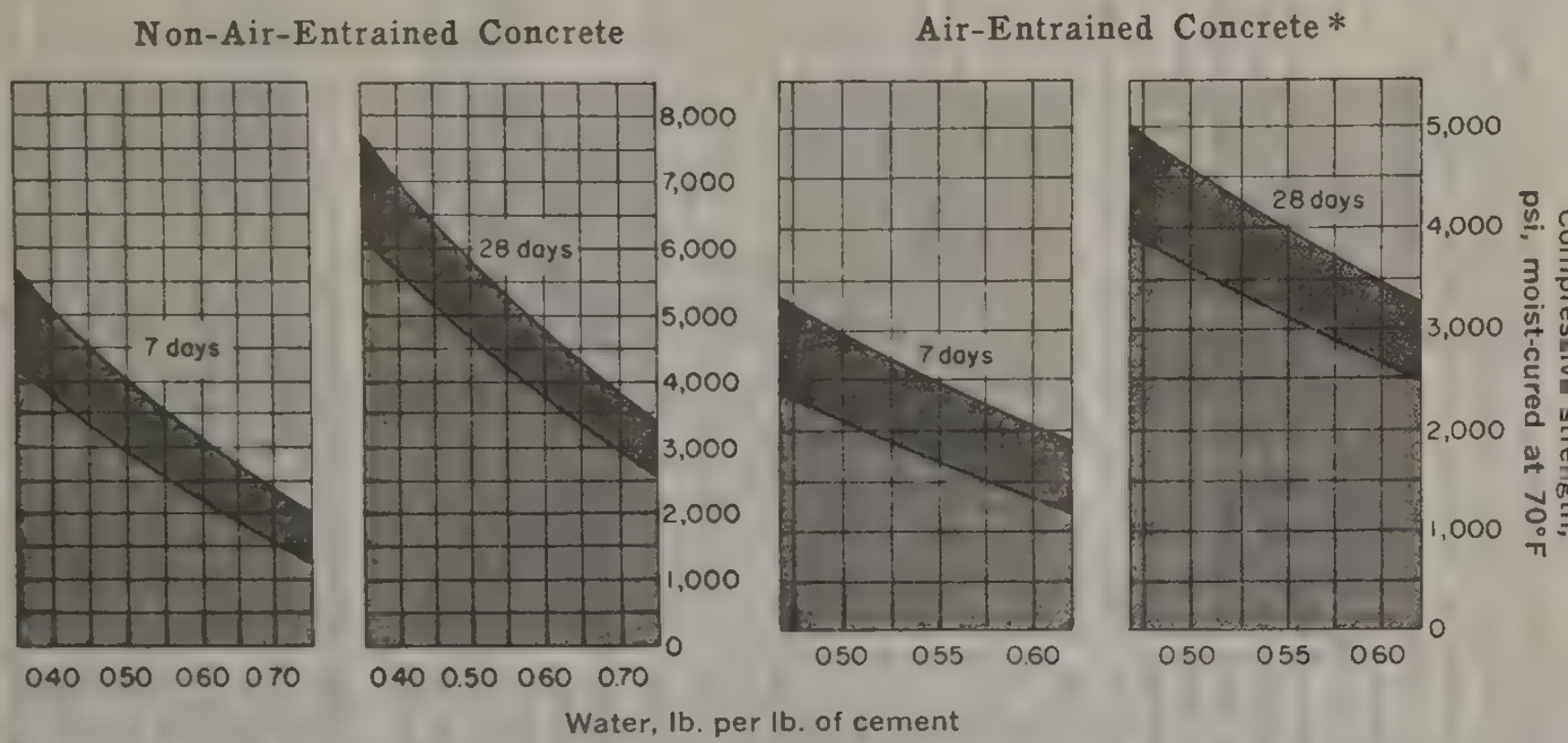
American Concrete Institute Standard for Selecting Proportions for Concrete Mixes

Committee 211 of the American Concrete Institute recommends certain practices for selecting proportions for concrete mixes. Following are extracts from this Standard which should be of value to all users of concrete.

BASIC RELATIONSHIP

Concrete proportions must be selected to provide necessary placeability, strength, and durability for the particular application. Well established relationships governing these properties are discussed briefly below.

Placeability (including satisfactory finishing properties) encompasses traits loosely accumulated in the terms "workability" and "consistency." For the purpose of this discussion, **workability** is considered to be that property of concrete which determines its capacity to be placed and consolidated properly and to be finished



* Concrete with air content within recommended limits and maximum aggregate size of 2 in. or less

Fig. 1. Relationship between water-cement ratio and compressive strength for portland cements at different ages. These relationships are approximate and should be used only as a guide in lieu of data on job materials.

vithout harmful segregation. It embodies such concepts as mold-
ibility, cohesiveness, and compactability. It is affected by the grad-
ng, particle shape and proportions of aggregate, the amount of
cement, the presence of entrained air, admixtures, and the con-
istency of the mixture. Procedures in this recommended practice
ermit these factors to be taken into account to achieve satisfac-
ory placeability economically.

Consistency, loosely defined, is the wetness of the concrete mix-
ure. It is measured in terms of slump—the higher the slump the
vetter the mixture—and it affects the ease with which the con-
rete will flow during placement. It is related to but not synony-
nous with workability. In properly proportioned concrete, the unit
vater content required to produce a given slump will depend on
everal factors. Water requirement increases as aggregates be-
ome more angular and rough textured (but this disadvantage
nay be offset by improvements in other characteristics such as
ond to cement paste). Required mixing water decreases as the
naximum size of well graded aggregate is increased. It also
lecreases with the entrainment of air. Mixing water requirement
nay often be significantly reduced by certain admixtures.

Strength. Strength is an important characteristic of concrete,
ut other characteristics such as durability, permeability, and wear
esistance are often equally or more important. These may be
elated to strength in a general way but are also affected by factors
ot significantly associated with strength. For a given set of ma-
erials and conditions, concrete strength is determined by the net
uantity of water used per unit quantity of cement. The net water
ontent excludes water absorbed by the aggregates. Differences in
trength for a given water-cement ratio may result from changes
n: maximum size of aggregate; grading, surface texture, shape,
trength, and stiffness of aggregate particles; differences in cement
ypes and sources; air content; and the use of admixtures which
ffect the cement hydration process or develop cementitious prop-
rties themselves. To the extent that these effects are predictable
n the general sense, they are taken into account in this recom-
nended practice. However, in view of their number and complex-
ty, it should be obvious that accurate predictions of strength must
e based on trial batches or experience with the materials to be
sed.

Durability. Concrete must be able to endure those exposures
vhich may deprive it of its serviceability—freezing and thawing,
vetting and drying, heating and cooling, chemicals, de-icing
gents, and the like. Resistance to some of these may be enhanced

by use of special ingredients: low-alkali cement, pozzolans, o selected aggregate to prevent harmful expansion due to the alkali aggregate reaction which occurs in some areas when concrete i exposed in a moist environment; sulfate resisting cement or poz zolans for concrete exposed to sea water or sulfate-bearing soils or aggregate free of excessive soft particles where resistance t surface abrasion is required. Use of a low water-cement ratio wil prolong the life of concrete by reducing the penetration of ag gressive liquids. Resistance to severe weathering, particularl freezing and thawing, and to salts used for ice removal is greatl improved by incorporation of a proper distribution of entraine air. Entrained air should be used in all exposed concrete in cli mates where freezing occurs.

BACKGROUND DATA

To the extent possible, selection of concrete proportions shoul be based on test data or experience with the materials actually t be used. Where such background is limited or not available, esti mates given in this recommended practice may be employed.

The following information for available materials will be useful

- Sieve analyses of fine and coarse aggregates
- Unit weight of coarse aggregate
- Bulk specific gravities and absorptions of aggregates
- Mixing water requirements of concrete developed from ex perience with available aggregates
- Relationships between strength and water-cement ratio fo available combinations of cement and aggregate

Estimates from Tables 3 and 4, respectively, may be used whe the last two items of information are not available. As will b shown, proportions can be estimated without the knowledge o aggregate specific gravity and absorption (third item above).

PROCEDURE

Estimating the required batch weights for the concrete involve a sequence of logical, straightforward steps which, in effect, fi the characteristics of the available materials into a mixture suit able for the work. The question of suitability is frequently not lef to the individual selecting the proportions. The job specification may dictate some or all of the following:

- Maximum water-cement ratio
- Minimum cement content
- Air content
- Slump

Maximum size of aggregate
Strength
Other requirements relating to such things as strength over-design, admixtures, and special types of cement or aggregate

Regardless of whether the concrete characteristics are pre-ribed by the specifications or are left to the individual selecting e proportions, establishment of batch weights per cubic yard of ncrete can best be accomplished in the following sequence:

Step 1. Choice of slump. If slump is not specified, a value ap-opriate for the work can be selected from Table 1. The slump nges shown apply when vibration is used to consolidate the ncrete. Mixes of the stiffest consistency that can be placed ficiently should be used.

Table 1—Recommended Slumps For Various Types of Construction

Types of construction	Slump, in.	
	Maximum*	Minimum
einforced foundation walls and footings	3	1
lain footings, caissons, and substructure walls	3	1
eams and reinforced walls	4	1
uilding columns	4	1
avements and slabs	3	1
eavy mass concrete	3	1

*May be increased 1 in. for methods of consolidation other than vibration.

Step 2. Choice of maximum size of aggregate. Large maximum izes of well graded aggregates have less voids than smaller sizes. Hence, concretes with the larger-sized aggregates require less ortar per unit volume of concrete. Generally, the maximum size f aggregate should be the largest that is economically available nd consistent with dimensions of the structure. Ordinarily, the atio of the nominal maximum aggregate size to the minimum imension within which concrete must be placed should not ex-eed the value shown in Table 2.

Step 3. Estimation of mixing water and air content. The quantity f water per unit volume of concrete required to produce a given lump is dependent on the maximum size, particle shape and grad-ng of the aggregates, and on the amount of entrained air. It is not reatly affected by the quantity of cement. Table 3 provides esti-nates of required mixing water for concretes made with various

Table 2—Recommended Maximum Ratio of Nominal Aggregate Size to Minimum Criterion Dimension

Criterion dimension		Recommended maximum ratio
Narrowest dimension between sides of forms		1/5
Depth of slab		1/3
Clear spacing between individual reinforcing bars, bundles of bars, or pre-tensioning strands	In columns	2/3
	In all other members	3/4

These limitations are sometimes waived if workability and methods of consolidation are such that the concrete can be placed without honeycomb or void. When high strength concrete is desired, best results may be obtained with reduced maximum sizes of aggregate since these produce higher strengths at a given water-cement ratio.

maximum sizes of aggregate, with and without air entrainment. Depending on aggregate texture and shape, mixing water requirements may be somewhat above or below the tabulated values, but they are sufficiently accurate for the first estimate. Such differences in water demand are not necessarily reflected in strength since other compensating factors may be involved. For example, a rounded and an angular coarse aggregate, both well and similarly graded and of good quality, can be expected to produce concrete of about the same compressive strength for the same cement factor in spite of differences in water-cement ratio resulting from the different mixing water requirements. Particle shape per se is not an indicator that an aggregate will be either above or below average in its strength-producing capacity.

Table 3 indicates the approximate amount of entrapped air to be expected in non-air-entrained concrete, and shows the recommended levels of average air content for concrete in which air is to be purposely entrained for durability. Air-entrained concrete should always be used for structures which will be exposed to freezing and thawing, and generally for structures exposed to sea water or sulfates. When severe exposure is not anticipated, beneficial effects of air entrainment on concrete workability and cohesiveness can be achieved at air content levels approximately half those shown for air-entrained concrete.

When trial batches are used to establish strength relationships or verify strength-producing capability of a mixture, the least favorable combination of mixing water and air content should be used. This is, the air content should be the maximum permitted or

Table 3—Approximate Mixing Water and Air Content Requirements for Different Slumps and Maximum Sizes of Aggregates*

Slump, in.	Water, lb. per cu. yd. of concrete for indicated maximum sizes of aggregate						
	⅜ in.	½ in.	¾ in.	1 in.	1½ in.	2 in.	3 in.
	Non-air-entrained concrete						
1 to 2	350	335	315	300	275	260	240
3 to 4	385	365	340	325	300	285	265
6 to 7	410	385	360	340	315	300	285
Air content, percent	3	2.5	2	1.5	1	0.5	0.3
	Air-entrained concrete						
1 to 2	305	295	280	270	250	240	225
3 to 4	340	325	305	295	275	265	250
6 to 7	365	345	325	310	290	280	270
Air content, percent	8	7	6	5	4.5	4	3.5

*These quantities of mixing water are for use in computing cement factors for trial batches. They are maxima for reasonably well-shaped angular coarse aggregates graded within limits of accepted specifications.

likely to occur, and the concrete should be gauged to the highest permissible slump. This will avoid developing an over-optimistic estimate of strength on the assumption that average rather than extreme conditions will prevail in the field. For information on air content recommendations, see ACI 201, 301, and 302.

Step 4. Selection of water-cement ratio. The required water-cement ratio is determined not only by strength requirements but also by factors such as durability and finishing properties. Since different aggregates and cements generally produce different strengths at the same water-cement ratio, it is highly desirable to have or develop the relationship between strength and water-cement ratio for the materials actually to be used. In the absence of such data, approximate and relatively conservative values for concrete containing Type I portland cement can be taken from Table 4(a). With typical materials, the tabulated water-cement ratios should produce the strengths shown, based on 28-day tests of specimens cured under standard laboratory conditions. The average strength selected must, of course, exceed the specified

strength by a sufficient margin to keep the number of low tests within specified limits.

For severe conditions of exposure, the water-cement ratio should be kept low even though strength requirements may be met with a higher value. Table 4(b) gives limiting values.

Table 4(a)—Relationships Between Water-Cement Ratio and Compressive Strength of Concrete

Compressive strength at 28 days, psi*	Water-cement ratio, by weight	
	Non-air-entrained concrete	Air-entrained concrete
6000	0.41	—
5000	0.48	0.40
4000	0.57	0.48
3000	0.68	0.59
2000	0.82	0.74

*Values are estimated average strengths for concrete containing not more than the percentage of air shown in Table 3. For a constant water-cement ratio the strength of concrete is reduced as the air content is increased.

Strength is based on 6 x 12 in. cylinders moist-cured 28 days at 73.4 ± 3 F (23 ± 1.7 C) in accordance with Section 9(b) of ASTM C 31 for Making and Curing Concrete Compression and Flexure Test Specimens in the Field.

Relationship assumes maximum size of aggregate about ¾ to 1 in.; for a given source, strength produced for a given water-cement ratio will increase as maximum size of aggregate decreases.

Table 4(b)—Maximum Permissible Water-Cement Ratios for Concrete in Severe Exposures*

Type of structure	Structure wet continuously or frequently and exposed to freezing and thawing†	Structure exposed to sea water or sulfates
Thin sections (railings, curbs, sills, ledges, ornamental work) and sections with less than 1 in. cover over steel	0.45	0.40‡
All other structures	0.50	0.45‡

*Based on report of ACI Committee 201, "Durability of Concrete in Service," previously cited

†Concrete should also be air-entrained.

‡If sulfate resisting cement (Type II or Type V of ASTM C 150) is used, permissible water-cement ratio may be increased by 0.05.

Step 5. Calculation of cement content. The amount of cement per unit volume of concrete is fixed by the determinations made in Steps 3 and 4 above. The required cement is equal to the estimated mixing water content (Step 3) divided by the water-cement ratio (Step 4). If, however, the specification includes a separate minimum limit on cement in addition to requirements for strength and durability, the mixture must be based on whichever criterion leads to the larger amount of cement.

Step 6. Estimation of coarse aggregate content. Aggregates of essentially the same maximum size and grading will produce concrete of satisfactory workability when a given volume of coarse aggregate, on a dry-rodded basis, is used per unit volume of concrete. Appropriate values for this aggregate volume are given in Table 6. It can be seen that, for equal workability, the volume of coarse aggregate in a unit volume of concrete is dependent only on its maximum size and the fineness modulus of the fine aggregate. Differences in the amount of mortar required for workability with different aggregates, due to differences in particle shape and grading, are compensated for automatically by differences in dry-rodded void content.

The volume of aggregate, in cubic feet, on a dry-rodded basis, for a cubic yard of concrete is equal to the value from Table 6 multiplied by 27. This volume is converted to dry weight of coarse

Table 6—Volume of Coarse Aggregate Per Unit of Volume of Concrete

Maximum size of aggregate, in.	Volume of dry-rodded coarse aggregate* per unit volume of concrete for different fineness moduli of sand			
	2.40	2.60	2.80	3.00
⅜	0.50	0.48	0.46	0.44
½	0.59	0.57	0.55	0.53
¾	0.66	0.64	0.62	0.60
1	0.71	0.69	0.67	0.65
1½	0.75	0.73	0.71	0.69
2	0.78	0.76	0.74	0.72
3	0.82	0.80	0.78	0.76

*Volumes are based on aggregates in dry-rodded condition as described in ASTM C 29 for Unit Weight of Aggregate.

These volumes are selected from empirical relationships to produce concrete with a degree of workability suitable for usual reinforced construction. For less workable concrete such as required for concrete pavement constuction they may be increased about 10 percent. When placement is to be by pump, they should be reduced about 10 percent.

aggregate required in a cubic yard of concrete by multiplying it by the dry-rodded weight per cubic foot of the coarse aggregate.

Step 7. Estimation of fine aggregate content. At completion of Step 6, all ingredients of the concrete have been estimated except the fine aggregate. Its quantity is determined by difference. Either of two procedures may be employed: the "weight" method or the "absolute volume" method:

If the weight of the concrete per unit volume is assumed or can be estimated from experience, the required weight of fine aggregate is simply the difference between the weight of fresh concrete and the total weight of the other ingredients. Often the unit weight of concrete is known with reasonable accuracy from previous experience with the materials. In the absence of such information, Table 7 can be used to make a first estimate. Even if the estimate of concrete weight per cubic yard is rough, mixture proportions will be sufficiently accurate to permit easy adjustment on the basis of trial batches as will be shown in the examples.

If a theoretically exact calculation of fresh concrete weight per cubic yard is desired, the following formula can be used:

$$U = 16.85\ G_a\ (100 - A) + C(1 - G_a/G_c) - W(G_a - 1)$$

where

U = weight of fresh concrete per cubic yard, lb.
G_a = weighted average specific gravity of combined fine and coarse aggregate, bulk SSD*
G_c = specific gravity of cement (generally 3.15)
A = air content, percent
W = mixing water requirement, lb. per cu. yd.
C = cement requirement, lb. per cu. yd.

A more exact procedure for calculating the required amount of fine aggregate involves the use of volumes displaced by the ingredients. In this case, the total volume displaced by the known ingredients—water, air, cement, and coarse aggregate—is subtracted from the unit volume of concrete to obtain the required volume of fine aggregate. The volume occupied in concrete by any ingredient is equal to its weight divided by the density of that material (the latter being the product of the unit weight of water and the specific gravity of the material).

Step 8. Adjustments for aggregate moisture. The aggregate

*SSD indicates saturated-surface-dry basis used in considering aggregate displacement. The aggregate specific gravity used in calculations must be consistent with the moisture condition assumed in the basic aggregate batch weights i.e., bulk dry if aggregate weights are stated on a dry basis, and bulk SSD if weights are stated on a saturated-surface-dry basis.

Table 7—First Estimate of Weight of Fresh Concrete

Maximum size of aggregate, in.	First estimate of concrete weight, lb. per cu. yd.*	
	Non-air-entrained concrete	Air-entrained concrete
⅜	3840	3690
½	3890	3760
¾	3960	3840
1	4010	3900
1½	4070	3960
2	4120	4000
3	4160	4040

*Values calculated by Eq. 7 for concrete of medium richness (550 lb. of cement per cu. yd.) and medium slump with aggregate specific gravity of 2.7. Water requirements based on values for 3 to 4 in. slump in Table 3. If desired, the estimated weight may be refined as follows if necessary information is available: for each 10 lb. difference in mixing water from the Table 3 values for 3 to 4 in. slump, correct the weight per cu. yd. 15 lb. in the opposite direction; for each 100 lb. difference in cement content from 550 lb., correct the weight per cu. yd. 15 lb. in the same direction; for each 0.1 by which aggregate specific gravity deviates from 2.7, correct the concrete weight 100 lb. in the same direction.

quantities actually to be weighed out for the concrete must allow for moisture in the aggregates. Generally, the aggregates will be moist and their dry weights should be increased by the percentage of water they contain, both absorbed and surface. The mixing water added to the batch must be reduced by an amount equal to the free moisture contributed by the aggregate—i.e., total moisture minus absorption.

Step 9. Trial batch adjustments. The calculated mixture proportions should be checked by means of trial batches prepared and tested in accordance with ASTM C 192, "Making and Curing Concrete Compression and Flexure Test Specimens in the Laboratory," or full-sized field batches. Only sufficient water should be used to produce the required slump regardless of the amount assumed in selecting the trial proportions. The concrete should be checked for unit weight and yield (ASTM C 138) and for air content (ASTM C 138, C 173, or C 231). It should also be carefully observed for proper workability, freedom from segregation, and finishing properties. Appropriate adjustments should be made in the proportions for subsequent batches in accordance with the following procedure.

Re-estimate the required mixing water per cubic yard of concrete by multiplying the net mixing water content of the trial batch by 27 and dividing the product by the yield of the trial batch

in cubic feet. If the slump of the trial batch was not correct, increase or decrease the re-estimated amount of water by 10 lb. for each required increase or decrease of 1 in. in slump.

If the desired air content (for air-entrained concrete) was not achieved, re-estimate the admixture content required for proper air content and reduce or increase the mixing water content of the above paragraph by 5 lb. for each 1 percent by which the air content is to be increased or decreased from that of the previous trial batch.

If estimated weight per cubic yard of fresh concrete is the basis for proportioning, re-estimate that weight by multiplying the unit weight in pounds per cubic foot of the trial batch by 27 and reducing or increasing the result by the anticipated percentage increase or decrease in air content of the adjusted batch from the first trial batch.

Calculate new batch weights starting with Step 4, modifying the volume of coarse aggregate from Table 6 if necessary to provide proper workability.

SAMPLE COMPUTATIONS

Two example problems will be used to illustrate application of the proportioning procedures. The following conditions are assumed:

Type I non-air-entraining cement will be used and its specific gravity is assumed to be 3.15.*

Coarse and fine aggregates in each case are of satisfactory quality and are graded within limits of generally accepted specifications.†

The coarse aggregate has a bulk specific gravity of 2.68* and an absorption of 0.5 percent.

The fine aggregate has a bulk specific gravity of 2.64,* an absorption of 0.7 percent, and fineness modulus of 2.8.

Example 1. Concrete is required for a portion of a structure which will be below ground level in a location where it will not be exposed to severe weathering or sulfate attack. Structural considerations require it to have an average 28-day compressive strength of 3500 psi.‡ On the basis of information in Table 1 as well as previous experience, it is determined that under the con-

*The specific gravity values are not used if proportions are selected to provide a weight of concrete assumed to occupy 1 cu. yd.

†Such as the "Specifications for Concrete Aggregates," (ASTM C 33).

‡This is not the specified strength used for structural design but a higher figure expected to be produced on the average. For the method of determining the amount by which average strength should exceed design strength, see "Recommended Practice for Evaluation of Compression Test Results of Field Concrete (ACI 214-65)."

ditions of placement to be employed, a slump of 3 to 4 in. be used and that the available No. 4 to 1½-in. coarse aggregate will be suitable. The dry-rodded weight of coarse aggregate is found to be 100 lb. per cu. ft. Employing the sequence outlined in the Procedure section, the quantities of ingredients per cubic yard of concrete are calculated as follows:

Step 1. As indicated above, the desired slump is 3 to 4 in.

Step 2. The locally available aggregate graded from No. 4 to 1½ in., has been indicated as suitable.

Step 3. Since the structure will not be exposed to severe weathering, non-air-entrained concrete will be used. The approximate amount of mixing water to produce a 3- to 4-in. slump in non-air-entrained concrete with 1½-in. aggregate is found from Table 3 to be 300 lb. per cu. yd. Estimated entrapped air is shown as 1 percent.

Step 4. From Table 4(a), the water-cement ratio needed to produce a strength of 3500 psi in non-air-entrained concrete is found to be about 0.62.

Step 5. From the information derived in Steps 3 and 4, the required cement content is found to be $300/0.62 = 484$ lb. per cu. yd.

Step 6. The quantity of coarse aggregate is estimated from Table 6. For a fine aggregate having a fineness modulus of 2.8 and a 1½ in. maximum size of coarse aggregate, the table indicates that 0.71 cu. ft. of coarse aggregate, on a dry-rodded basis, may be used in each cubic foot of concrete. For a cubic yard, therefore, the coarse aggregate will be $27 \times 0.71 = 19.17$ cu. ft. Since it weighs 100 lb. per cu. ft. the dry weight of coarse aggregate is 1917 lb.

Step 7. With the quantities of water, cement, and coarse aggregate established, the remaining material comprising the cubic yard of concrete must consist of sand and whatever air will be entrapped. The required sand may be determined on the basis of either weight or absolute volume as shown below:

Weight basis. From Table 7, the weight of a cubic yard of non-air-entrained concrete made with aggregate having a maximum size of 1½ in. is estimated to be 4070 lb. (For a first trial batch, exact adjustments of this value for usual differences in slump, cement factor, and aggregate specific gravity are not critical.) Weights already known are:

Water (net mixing)	300 lb.
Cement	484 lb.
Coarse aggregate	1917 lb. (dry)*
Total	2701 lb.

*Aggregate absorption is disregarded since its magnitude is inconsequential in relation to other approximations.

The weight of sand, therefore, is estimated to be

$$4070 - 2701 = 1369 \text{ lb. (dry)}^*$$

Absolute volume basis. With the quantities of cement, water, and coarse aggregate established, and the approximate entrapped air content (as opposed to purposely entrained air) taken from Table 3, the sand content can be calculated as follows:

$$\text{Volume of water} = \frac{300}{62.4} = 4.81 \text{ cu. ft.}$$

$$\text{Solid volume of cement} = \frac{484}{3.15 \times 62.4} = 2.46 \text{ cu. ft.}$$

$$\text{Solid volume of coarse aggregate} = \frac{1917}{2.68 \times 62.4} = 11.46 \text{ cu. ft.}$$

$$\text{Volume of entrapped air} = 0.01 \times 27 = 0.27 \text{ cu. ft.}$$

$$\text{Total solid volume of ingredients except sand} = 19.00 \text{ cu. ft.}$$

$$\text{Solid volume of sand required} = 27 - 19.00 = 8.00 \text{ cu. ft.}$$

$$\text{Required weight of dry sand} = 8.00 \times 2.64 \times 62.4 = 1318 \text{ lb.}$$

Batch weights per cubic yard of concrete calculated on the two bases are compared below:

	Based on estimated concrete weight, lb.	Based on absolute volume of ingredients, lb.
Water (net mixing)	300	300
Cement	484	484
Coarse aggregate (dry)	1917	1917
Sand (dry)	1369	1318

Note: These batch weights will require adjustment in the field to take into account moisture on aggregates. Also, some adjustment in proportions may be found desirable on the basis of actual field experience.

*Aggregate absorption is disregarded since its magnitude is inconsequential in relation to other approximations.

Example 2. Concrete is required for a heavy bridge pier which will be exposed to fresh water in a severe climate. An average 28-day compressive strength of 3000 psi will be required. Placement conditions permit a slump of 1 to 2 in. and the use of large aggregate, but the only economically available coarse aggregate of satisfactory quality is graded from No. 4 to 1 in. and this will be used. Its dry-rodded weight is found to be 95 lb. per cu. ft. Other characteristics are as indicated in the first part of this section.

The calculations will be shown in skeleton form only. Note that confusion is avoided if all steps of the Procedure section are followed even when they appear repetitive of specified requirements.

Step 1. The desired slump is 1 to 2 in.

Step 2. The locally available aggregate, graded from No. 4 to 1 in., will be used.

Step 3. Since the structure will be exposed to severe weathering, air-entrained concrete will be used. The approximate amount of mixing water to produce a 1 to 2-in. slump in air-entrained concrete with 1-in. aggregate is found from Table 3 to be 270 lb. per cu. yd. The recommended air content is 5 percent.

Step 4. From Table 4(a), the water-cement ratio needed to produce a strength of 3000 psi in air-entrained concrete is estimated to be about 0.59. However, reference to Table 4(b) reveals that, for the severe weathering exposure anticipated, the water-cement ratio should not exceed 0.50. This lower figure must govern and will be used in the calculations.

Step 5. From the information derived in Steps 3 and 4, the required cement content is found to be $270/0.50 = 540$ lb. per cu. yd.

Step 6. The quantity of coarse aggregate is estimated from Table 6. With a fine aggregate having a fineness modulus of 2.8 and a 1 in. maximum size of coarse aggregate, the table indicates that 0.67 cu. ft. of coarse aggregate, on a dry-rodded basis, may be used in each cubic foot of concrete. For a cubic yard, therefore, the coarse aggregate will be $27 \times 0.67 = 18.09$ cu. ft. Since it weighs 95 lb. per cu. ft., the dry weight of coarse aggregate is $18.09 \times 95 = 1719$ lb.

Step 7. With the quantities of water, cement and coarse aggregate established, the remaining material comprising the cubic yard of concrete must consist of sand and air. The required sand may be determined on the basis of either weight or absolute volume as shown below.

Weight basis. From Table 7, the weight of a cubic yard of air-entrained concrete made with aggregate of 1 in. maximum size is estimated to be 3900 lb. (For a first trial batch, exact adjustments

of this value for differences in slump, cement factor, and aggregate specific gravity are not critical.) Weights already known are:

Water (net mixing)	270 lb.
Cement	540 lb.
Coarse aggregate (dry)	1719 lb.
Total	2529 lb.

The weight of sand, therefore, is estimated to be

$$3900 - 2529 = 1371 \text{ lb. (dry)}$$

Absolute volume basis. With the quantities of cement, water, air, and coarse aggregate established, the sand content can be calculated as follows:

$$\text{Volume of water} = \frac{270}{62.4} = 4.33 \text{ cu. ft.}$$

$$\text{Solid volume of cement} = \frac{540}{3.15 \times 62.4} = 2.75 \text{ cu. ft.}$$

$$\text{Solid volume of coarse aggregate} = \frac{1719}{2.68 \times 62.4} = 10.28 \text{ cu. ft.}$$

$$\text{Volume of air} = 0.05 \times 27 = 1.35 \text{ cu. ft.}$$

$$\text{Total volume of ingredients except sand} = 18.71 \text{ cu. ft.}$$

$$\text{Solid volume of sand required} = 27 - 18.71 = 8.29 \text{ cu. ft.}$$

$$\text{Required weight of dry sand} = 8.29 \times 2.64 \times 62.4 = 1366 \text{ lb.}$$

Batch weight per cubic yard of concrete calculated on the two bases are compared below:

	Based on estimated concrete weight, lb.	Based on absolute volume of ingredients, lb.
Water (net mixing)	270	270
Cement	540	540
Coarse aggregate (dry)	1719	1719
Sand (dry)	1371	1366

See note at end of Example 1

READY-MIXED CONCRETE

In the United States more than 90 percent of all concrete being used in building projects is ready-mixed. Ready-mixed concrete may be defined as portland cement concrete manufactured for delivery to a purchaser in a plastic and unhardened state.

In some instances the concrete is mixed completely in a stationary mixer and then is transported to the job in trucks. This is known as central-mixed concrete. In other ready-mixed operations, the materials are dry batched and mixed en route to the job in truck mixers. This is known as transit mixed concrete. In another procedure, the concrete is mixed in a stationary mixer at the central plant only enough to intermingle the ingredients, usually about ½ minute, and the mixing is completed en route to the job. This is known as shrink-mixed concrete.

Truck mixers consist essentially of a mixer with a separate water tank and water measuring device mounted on a truck chassis. There are other truck conveyances which are similar but are without provisions for water.

ASTM C-94 requires that when a truck mixer is used either for complete mixing or to finish the partial mixing, each batch of concrete is to be mixed not more than 100 revolutions of the drum or blades at the speed of rotation designated by the manufacturer as the mixing speed. Any additional mixing is to be done at the agitating speed. The specification also requires that the concrete must be delivered and discharged from the truck mixer or agitator truck within 1½ hours after introduction of the water to the cement and aggregate or the cement to the aggregate.

Quality of Ready-Mixed Concrete. ASTM C-94 states that in the absence of applicable general specifications, the purchaser shall select one of two alternate bases for specifying the quality of concrete.

Alternate No. 1:

When the purchaser assumes responsibility for the proportioning of the concrete mixture, he shall also specify the following:

(1) Cement content in bags or pounds per cubic yard of concrete, or equivalent units.

(2) Maximum allowable water content in gallons per cubic yard of concrete, or equivalent units, including surface moisture on the aggregates, but excluding water of absorption.

(3) If admixtures are required, the type, name, and dosage to be used. The cement content shall not be reduced when admixtures are used under Alternate No. 1 without the written approval of the purchaser.

Alternate No. 2:

When the purchaser requires the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture, the purchaser shall also specify the following:

Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge. The purchaser shall specify the requirements in terms of the compressive strength of standard specimens cured under standard laboratory conditions for moist curing. Unless otherwise specified the age at test shall be 28 days.

Alternate No. 3:

When the purchaser requires the manufacturer to assume responsibility for the selection of the proportions for the concrete mixture with the minimum allowable cement content specified, the purchaser shall also specify the following:

(1) Required compressive strength as determined on samples taken from the transportation unit at the point of discharge. The purchaser shall specify the requirements for strength in terms of tests of standard specimens cured under standard laboratory conditions for moist curing. Unless otherwise specified the age at test shall be 28 days.

(2) Minimum cement content in bags or pounds per cubic yard of concrete.

(3) If admixtures are required, the type, name, and dosage to be used. The cement content shall not be reduced when admixtures are used.

Note:—Alternate No. 3 can be distinctive and useful only if the designated minimum cement content is at about the same level that would ordinarily be required for the strength, aggregate size, and slump specified. At the same time, it must be an amount that will be sufficient to assure durability under expected service conditions as well as satisfactory surface texture and density, in the event specified strength is attained with it.

The proportions arrived at by Alternates 1, 2, or 3 for each class of concrete and approved for use in a project shall be assigned to a designation to facilitate identification of each concrete mixture delivered to the project. This is the designation required and supplies information on concrete proportions when they are not given separately on each delivery ticket. A certified copy of all proportions as established in Alternates 1, 2, and 3 shall be on file at the batch plant.

Curing.—The protection of concrete during the early period to prevent loss of moisture or low temperatures is an important factor in the development of both strength and durability in con-

crete. Specifications require that the concrete be protected to prevent loss of moisture from the surface and to prevent temperatures at the surface from going below 50 deg. F. for periods of 5 days where normal portland cement is used, and 3 days where high early strength portland cement is used.

In fixing these limits it is recognized that under average conditions, curing of concrete does not cease immediately upon removal of the protection against loss of moisture. Where the conditions are extremely severe, such as for thin sections in hot dry air or very low temperatures, it may be desirable to increase somewhat the protection periods specified.

High Early Strength Portland Cement.—Most of the cement companies are now manufacturing what is designated as high early strength portland cement, which develops practically the same strength in 72 hours as is obtained with normal portland cement in 7 to 10 days.

High early strength cement is used in the same proportions and in exactly the same manner as ordinary portland cement and it is becoming general knowledge with contractors that this cement is of advantage not only in special rush work but in every day reinforced concrete construction. High early strength cement at present costs 50 cents per barrel more than standard portland cement, or, if we assume that approximately 1½ barrels of cement per cu. yd. will be used, the cost per cu. yd. of concrete is increased by 75 cents. If the average amount of concrete per sq. ft. of floor construction (including columns, beams, lintels, etc.) is 8", it takes 40 sq. ft. of floor for a yard of concrete, or the extra expense on account of the use of high early strength cement is 3 cents per sq. ft.

Under favorable conditions it is possible to strip part or an entire floor in two days so it may be possible to save half or more of the lumber required for a floor. Under "Reinforced Concrete" it is shown that it takes not less than 3 ft. of lumber, b.m. for each sq. ft. of floor construction (including columns, girders and lintels) besides it costs 4 to 5 cents per sq. ft. of floor to make up the various sides, panels, shores, wedges, etc. required. If it is possible to save only one-half of the lumber, the saving is 13 cents per sq. ft. plus half the saving of the make up, or 2 cts. resulting in a possible saving of 15 cts. per sq. ft. This is quite out of proportion to the expense of 3 cts. for the extra cost of cement.

During the winter there is the additional saving of two to three days for cold weather protection, coke, attendants, etc.

Air Entrained Concrete.—Most of the highway departments are specifying air-entrained concrete for pavements and many

require it for bridges and other structures. In this concrete 3 to 5 or 6 percent of air is incorporated in the concrete in the form of minute separated air bubbles. Such concrete is more resistant to freezing and thawing and to salt action than normal concrete. It is produced by using air-entraining portland cement or by the addition of an air-entraining agent at the mixer. Originally developed to prevent scaling of pavement where salts are used for ice removal, air-entrained concrete is being widely adopted for all types of work and in all locations because of its better workability as well as its better resistance to weathering even where salts are not used.

In air-entrained concrete the proportion of sand and the amount of water is generally reduced from the normal mix in sufficient quantities to make up for the increased volume of concrete produced by the air. Thus the same cement factor is maintained. In the tables given on the previous pages, the sand can be reduced about 5 lbs. for each 1 percent of air. Thus, if 4 percent air is incorporated, the quantities of sand shown in these tables would be reduced by 20 lbs. per cubic yard of concrete. For each 1 percent of air the amount of water would be reduced by about 6 to 7 lbs. per cubic yard.

Important Suggestions Regarding the Purchasing of Materials for Job Mixed Concrete.—When purchasing sand, gravel or crushed stone for concrete, it is important to see that the aggregates and particularly the sand do not contain an abnormal amount of moisture, otherwise you will be short on materials, which will reduce profits or may even result in a loss, particularly if there are considerable quantities of aggregates to be purchased.

The following suggestions are important when placing orders:

1. Determine whether the sand has a high or low moisture content.
2. Determine whether the sand has a high or low specific gravity.
3. When sand is purchased at a certain price per cu. yd. make certain that you are not paying for water instead of sand, as it is not uncommon to see settlement of 4" in trucks or railroad cars from the time it is shipped to the time it arrives at the job. This is especially true where washed sand is loaded immediately after washing or after hard rains. This is extremely important.
4. When sand is purchased by weight, also make certain you are not paying for water instead of sand. Ordinarily sand should not contain over 4 to 5 percent moisture, while wet sand may contain as high as 18 percent moisture. This makes a big difference in the cost of your sand.

5. Watch the grading of your sand and percentages of from fine to coarse.
6. Determine the grading of the gravel and its specific gravity.
7. When gravel is purchased by the cu. yd. stipulate measurement at job or destination, if possible.
8. When gravel is purchased by weight, weight at destination should govern instead of weight at loading point, when gravel may contain much moisture.
9. When purchasing crushed stone, obtain the grading and specific gravity.
10. When purchasing crushed stone, determine the weight per cu. yd. also the moisture content. It means real money on a big job.

An easy method of determining the moisture content of sand, gravel or crushed stone, is to measure out one cu. ft. of each and weigh them. Then dry this same material and weigh it. The difference in weight is the moisture content. Example: If one cu. ft. of loose damp sand weighs 105 lbs. and after drying it weighs only 90 lbs. then the moisture content is 15 lbs. or 16⅔ percent.

Quantities of Materials Required for Job-Mixed Concrete.—For estimating purposes, material quantities for job mixed concrete given in the following table may be used as a guide. The quantities shown in the table will produce concrete of medium consistency or with a slump of about 3″ to 4″.

Labor Mixing and Placing Concrete

The labor cost of mixing and placing concrete will vary considerably according to the size of the job, the method used in mixing and placing the concrete, the proximity of the stock piles to the mixer, and the distance the concrete has to be transported after mixing.

On large jobs using conveyors and bins for feeding the aggregate to the mixer the purchase or rental of this equipment, together with the labor cost of placing same, should be estimated separately and not included in the cu. yd. price of placing the concrete. This plant and equipment cost may be the same whether the job contains 1,000 or 10,000 cu. yds. of concrete, and unless it is kept as a separate item, the resulting labor costs will be misleading and valueless insofar as estimating the cost of future jobs are concerned.

Ready-mix concrete is used in all parts of the country today and where the concrete is delivered to the job mixed and ready to place in the forms, it is often possible for the truck mixers to deposit the concrete directly into the trenches or wall forms

SUGGESTED MIXES FOR NON-AIR-ENTRAINED CONCRETE OF MEDIUM CONSISTENCY

(3- to 4-in. slump)*

Water-cement ratio, lb. per lb.	Maximum size of aggregate, in.	Air content (entrapped air), per cent	Water, lb. per cu.yd. of concrete	Cement, lb. per cu.yd. of concrete	With fine sand—fineness modulus = 2.50**			With coarse sand—fineness modulus = 2.90**		
					Fine aggregate, per cent of total aggregate	Fine aggregate, lb. per cu.yd of concrete	Coarse aggregate, lb. per cu.yd. of concrete	Fine aggregate, per cent of total aggregate	Fine aggregate, lb. per cu yd of concrete	Coarse aggregate, lb per cu yd of concrete
0.40	⅜	3	385	965	50	1240	1260	54	1350	1150
	½	2.5	365	915	42	1100	1520	47	1220	1400
	¾	2	340	850	35	960	1800	39	1080	1680
	1	1.5	325	815	32	910	1940	36	1020	1830
	1½	1	300	750	29	880	2110	33	1000	1990
0.45	⅜	3	385	855	51	1330	1260	56	1440	1150
	½	2.5	365	810	44	1180	1520	48	1300	1400
	¾	2	340	755	37	1040	1800	41	1160	1680
	1	1.5	325	720	34	990	1940	38	1100	1830
	1½	1	300	665	31	960	2110	35	1080	1990
0.50	⅜	3	385	770	53	1400	1260	57	1510	1150
	½	2.5	365	730	45	1250	1520	49	1370	1400
	¾	2	340	680	38	1100	1800	42	1220	1680
	1	1.5	325	650	35	1050	1940	39	1160	1830
	1½	1	300	600	32	1010	2110	36	1130	1990
0.55	⅜	3	385	700	54	1460	1260	58	1570	1150
	½	2.5	365	665	46	1310	1520	51	1430	1400
	¾	2	340	620	39	1150	1800	43	1270	1680
	1	1.5	325	590	36	1100	1940	40	1210	1830
	1½	1	300	545	33	1060	2110	37	1180	1990
0.60	⅜	3	385	640	55	1510	1260	58	1620	1150
	½	2.5	365	610	47	1350	1520	51	1470	1400
	¾	2	340	565	40	1200	1800	44	1320	1680
	1	1.5	325	540	37	1140	1940	41	1250	1830
	1½	1	300	500	34	1090	2110	38	1210	1990
0.65	⅜	3	385	590	55	1550	1260	59	1660	1150
	½	2.5	365	560	48	1390	1520	52	1510	1400
	¾	2	340	525	41	1230	1800	45	1350	1680
	1	1.5	325	500	38	1180	1940	41	1290	1830
	1½	1	300	460	35	1130	2110	39	1250	1990
0.70	⅜	3	385	550	56	1590	1260	60	1700	1150
	½	2.5	365	520	48	1430	1520	53	1550	1400
	¾	2	340	485	41	1270	1800	45	1390	1680
	1	1.5	325	465	38	1210	1940	42	1320	1830
	1½	1	300	430	35	1150	2110	39	1270	1990

*Increase or decrease water per cubic yard by 3 per cent for each increase or decrease of 1 in. in slump, then calculate quantities by absolute volume method. For manufactured fine aggregate, increase percentage of fine aggregate by 3 and water by 15 lb. per cubic yard of concrete. For less workable concrete, as in pavements, decrease percentage of fine aggregate by 3 and water by 8 lb. per cubic yard of concrete.

**For definition of fineness modulus, see *Aggregates for Concrete*, available from the Portland Cement Association.

SUGGESTED MIXES FOR AIR-ENTRAINED CONCRETE OF MEDIUM CONSISTENCY

(3- to 4-in. slump)*

Water-cement ratio lb. per lb	Maximum size of aggregate in	Air content, per cent	Water lb per cu yd of concrete	Cement, lb per cu yd of concrete	With fine sand—fineness modulus = 2.50**			With coarse sand—fineness modulus = 2.90**		
					Fine aggregate per cent of total aggregate	Fine aggregate lb per cu yd of concrete	Coarse aggregate lb per cu yd of concrete	Fine aggregate, per cent of total aggregate	Fine aggregate, lb. per cu.yd. of concrete	Coarse aggregate, lb per cu.yd. of concrete
0.40	⅜	7.5	340	850	50	1250	1260	54	1360	1150
	½	7.5	325	815	41	1060	1520	46	1180	1400
	¾	6	300	750	35	970	1800	39	1090	1680
	1	6	285	715	32	900	1940	36	1010	1830
	1½	5	265	665	29	870	2110	33	990	1990
0.45	⅜	7.5	340	755	51	1330	1260	56	1440	1150
	½	7.5	325	720	43	1140	1520	47	1260	1400
	¾	6	300	665	37	1040	1800	41	1160	1680
	1	6	285	635	33	970	1940	37	1080	1830
	1½	5	265	590	31	930	2110	35	1050	1990
0.50	⅜	7.5	340	680	53	1400	1260	57	1510	1150
	½	7.5	325	650	44	1200	1520	49	1320	1400
	¾	6	300	600	38	1100	1800	42	1220	1680
	1	6	285	570	34	1020	1940	38	1130	1830
	1½	5	265	530	32	980	2110	36	1100	1990
0.55	⅜	7.5	340	620	54	1450	1260	58	1560	1150
	½	7.5	325	590	45	1250	1520	49	1370	1400
	¾	6	300	545	39	1140	1800	43	1260	1680
	1	6	285	520	35	1060	1940	39	1170	1830
	1½	5	265	480	33	1030	2110	37	1150	1990
0.60	⅜	7.5	340	565	54	1490	1260	58	1600	1150
	½	7.5	325	540	46	1290	1520	50	1410	1400
	¾	6	300	500	40	1180	1800	44	1300	1680
	1	6	285	475	36	1100	1940	40	1210	1830
	1½	5	265	440	33	1060	2110	37	1180	1990
0.65	⅜	7.5	340	525	55	1530	1260	59	1640	1150
	½	7.5	325	500	47	1330	1520	51	1450	1400
	¾	6	300	460	40	1210	1800	44	1330	1680
	1	6	285	440	37	1130	1940	40	1240	1830
	1½	5	265	410	34	1090	2110	38	1210	1990
0.70	⅜	7.5	340	485	55	1560	1260	59	1670	1150
	½	7.5	325	465	47	1360	1520	51	1480	1400
	¾	6	300	430	41	1240	1800	45	1360	1680
	1	6	285	405	37	1160	1940	41	1270	1830
	1½	5	265	380	34	1110	2110	38	1230	1990

* and ** See references bottom of p. 302.

without any handling on the job, other than spading, vibrating, spreading and leveling the concrete.

However, on many jobs this is not possible and it is necessary to have a receiving hopper where the truck mixers dump the concrete and it is then hauled from receiving hopper to place of deposit either by wheelbarrows, hand or power buggies. On large operations the concrete may be pumped from receiving hopper to place of deposit.

Another method of placing the concrete that is often used on large operations is to use a crane with a long mast which picks

up an entire batch of concrete in a bucket and places it directly over the footings, piers or forms.

Where any of the above methods are used, all mixer labor is eliminated but it usually requires one or two men at the receiving hopper or at the truck dump to assist the truck mixer, prevent spillage, cleanup, etc.

Most specifications prohibit the use of long spouts for chuting concrete from the mixer to the forms on account of the great danger of segregation. Buggies or buckets are generally desirable. Self-propelled buggies are now available and are used on many of the larger jobs.

Weather conditions also influence the labor costs considerably because placing concrete in freezing weather usually necessitates heating the sand, gravel or stone and water, and protecting the concrete from freezing by the use of tarpaulins, straw, manure, coke or oil burning salamanders or other artificial means, all of which add to the overall expense.

With so many small mixers on the market very little concrete is hand mixed today, but occasionally a job presents itself where it is more economical to mix by hand, so costs will be given covering all different methods.

Mixes for Small Jobs

For small jobs where time and personnel are not available to determine proportions in accordance with the recommended procedure, mixes in Table 1 will usually provide concrete that is amply strong and durable if the amount of water added at the mixer is never large enough to make the concrete overwet. These mixes have been predetermined in conformity with the recommended procedure by assuming conditions applicable to the average small job, and for aggregate of medium specific gravity. Three mixes are given for each maximum size of coarse aggregate. For the selected size of coarse aggregate, Mix B is intended for initial use. If this mix proves to be oversanded, change to Mix C; if it is undersanded, change to Mix A. It should be noted that the mixes listed in the table are based on dry or surface-dry sand. If the sand is moist or wet, make the corrections in batch weight prescribed in the footnote.

The approximate cement content per cubic foot of concrete listed in the table will be helpful in estimating cement requirements for the job. These requirements are based on concrete that has just enough water in it to permit ready working into forms without objectionable segregation. Concrete should slide, not run off a shovel.

Table 1—Concrete Mixes for Small Jobs

Procedure: Select the proper maximum size of aggregate (see Step 2, p. 285). Use Mix B, adding just enough water to produce a workable consistency. If the concrete appears to be undersanded, change to Mix A and, if it appears oversanded, change to Mix C.

Maximum size of aggregate, in.	Mix designation	Approximate weights of solid ingredients per cu. ft. of concrete, lb.				
			Sand*		Coarse aggregate	
		Cement	Air-entrained concrete†	Concrete without air	Gravel or crushed stone	Iron blast furnace slag
½	A	25	48	51	54	47
	B	25	46	49	56	49
	C	25	44	47	58	51
¾	A	23	45	49	62	54
	B	23	43	47	64	56
	C	23	41	45	66	58
1	A	22	41	45	70	61
	B	22	39	43	72	63
	C	22	37	41	74	65
1½	A	20	41	45	75	65
	B	20	39	43	77	67
	C	20	37	41	79	69
2	A	19	40	45	79	69
	B	19	38	43	81	71
	C	19	36	41	83	72

*Weights are for dry sand. If damp sand is used, increase tabulated weight of sand 2 lb. and, if very wet sand is used, 4 lb.

†Air-entrained concrete should be used in all structures which will be exposed to alternate cycles of freezing and thawing. Air-entrainment can be obtained by the use of an air-entraining cement or by adding an air-entraining admixture. If an admixture is used, the amount recommended by the manufacturer will, in most cases, produce the desired air content.

The Prime Mover or Power Buggy.*—A method of transporting construction materials, such as wet concrete, earth, sand, gravel, cement, etc., is through the use of a prime mover or power operated buggy, which requires only steering on the part of the operator.

They are furnished in various sizes by different manufacturers and the cost varies according to size and capacity.

The Prime Mover* is mounted on a power driven three-wheel chassis and is steered by means of a rear caster wheel. The maximum speed over the ground conforms to a fast walking

*The Prime Mover Co., Muscatine, Iowa.

The Prime Mover Power Operated Buggy

pace either on the level or up to a 20 percent incline.

This machine has a capacity of 1,500 lbs.; a bucket volume of 10 cu. ft. and will handle 8 to 9 cu. ft. of wet concrete but a larger volume of light, dry materials. This buggy weighs 560 lbs. is powered by a 7 Hp. gasoline engine having a fuel capacity of 2¾ gals. which will operate the machine for eight hours. The machine is 5'-5½" in length overall, 2'-7½" wide and is furnished with either single or dual wheels and has a turning radius of 3'-¾".

Comparison of Hand and Power Buggy Operation.—The smaller power buggy having a capacity of 8 to 9 cu. ft. of wet concrete will probably do the work of three men pushing hand powered concrete buggies.

A large machine having a capacity of 10 to 13 cu. ft. of wet concrete, and a speed of 2 to 15 mi. per hr. will probably handle as much concrete as 4 to 5 men using hand operated buggies but it may be that heavier runways will be required to handle the larger loads of concrete.

The following is an approximate comparison of cost between the two methods; based on wheeling 100 cu. yds. of concrete from a 16-S mixer:

	Hours	Rate	Total	Rate	Total
5 laborers	40	$.....	$.....	$5.00	$200.00
Cost per cu. yd.	0.4				2.00
Power buggy method					
Power buggy, fixed charge.	8	.....	.....	0.50	4.00
Fuel, 4 gals. and oil		.....	.....	.40	1.60
Operator	8	.....	.....	5.00	40.00
Total cost per day	8		.....		$ 45.60
Cost per cu. yd.	0.08		.....		.456

On the above basis, there would be a saving of about ⅛-hr. labor time per cu. yd. of concrete.

On some jobs, it may be that 2 power buggies would be required to keep the mixer operating at capacity, and in such instances would be double that given above—but in either instance the saving is considerable.

Where a power buggy having a bucket capacity of 8 to 9 cu. ft. of wet concrete is used, it would require about one-third as much labor as where the buggies are pushed by hand, and the comparison of cost would be about as follows:

	Hours	Rate	Total	Rate	Total
6 laborers	48	$.....	$.....	$5.00	$240.00
Cost per cu. yd.	0.4		.....		2.00

Using two gasoline driven power buggies, the cost would be as follows:

Power buggy method	Hours	Rate	Total	Rate	Total
Power buggy, fixed charge	16	$.....	$.....	$0.50	$ 8.00
Gasoline, 6 gals. and oil	.....	.....	.....	.40	2.40
Laborers	16	.....	.....	5.00	80.00
Total cost per day	16		.....		$ 90.40
Cost per cu. yd.	0.133		.....		.753

Based on 120 cu. yds. for each crew, the saving would be about ¼-hr. labor time per cu. yd. of concrete.

Mixing Concrete in a One Sack (6-S) Mixer.—Foundation concrete is usually mixed in the proportions of 1:2:4, 1:3:5 or 1:3:6, which is a one sack mix using a 6-S mixer.

Often a 1:3:5 mix is used for foundation walls where watertight concrete is not necessary. This requires 1 sack of cement, 3 cu. ft. of dry sand and 5 cu. ft. of gravel or crushed stone, per batch. Wheelbarrows ordinarily used for dry materials hold 3 to 3½ cu. ft. loaded level full, so each batch will require 1 barrow of sand and 2 barrows of gravel or 9 cu. ft. of dry material.

Where possible to start mixing first thing in the morning and continue all day without delays, a mixer should average 30

batches (6 to 7 cu. ft. of concrete each) per hr. or 240 batches (54 to 62 cu. yds.), per 8-hr day. Runs like this on foundation work are exceptional, because in addition to the actual mixing time, it will be necessary to allow for delays, shutdowns, etc., as maximum output cannot be figured for the entire job, as the men must be paid for time getting ready to start work in the morning, cleaning and washing wheelbarrows or buggies and concrete mixer at noon and at night; cutting and removing old concrete drippings and spillage; building and removing runways; unloading cement; delays caused by non-delivery of materials, etc.

Based on 6 to 7 cu. yds. of concrete an hr. the following men will be required in the gang: 2 laborers loading and wheeling gravel or crushed stone; 2 laborers wheeling sand and cement; 1 laborer attending mixer; 3 or 4 laborers wheeling concrete from mixer to place of deposit; 2 or 3 laborers dumping barrows, spreading, leveling and tamping concrete; 1 mixer engineer (if required), and 1 mason foreman in charge of work (if required).

Allowing for average conditions, including runways, cleaning and repairing mixer, engine, etc., the labor per cu. yd. of concrete should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	2.5	$.....	$.....	$5.00	$12.50

Under extremely favorable conditions, this cost may be reduced ½ to ¾-hr. per cu. yd. Add for mason foreman and mixer engineer, if required by union rules.

If a power buggy is used for wheeling concrete from mixer to place of deposit, one power buggy will take away all the concrete a 6-S mixer can turn out. This will eliminate 2 to 3 laborers wheeling concrete and result in a saving of about ¼-hr. labor time per cu. yd. of concrete.

Mixing Concrete Using a 11-S Mixer.—When using a 11-S mixer of 1 to 2 sack mix capacity, the costs will run about the same as given for 6-S or 16-S mixers, under the same conditions.

Mixing Concrete in a 16-S (3 Sack Batch) Mixer.—A mixer of this size will turn out about 16 cu. ft. of mixed concrete at each batch, depending upon the proportions.

Opinions vary as to amount of mixing required. The time of mixing specified by architects and engineers usually varies between 1½ and 2 minutes per batch. The time specified affects the labor costs to a considerable extent as the longer mixing time restricts the day's output.

If the mixer has a side-loader and is fed by wheelbarrows with

the concrete wheeled direct from the mixer to place of deposit, in wheelbarrows or concrete buggies, the mixer should average one batch every 2 minutes or 30 batches (13 to 15 cu. yds.) an hr.

Using an average of 2 minutes per batch, the mixer should turn out 104 to 120 cu. yds. per 8-hr. day, depending upon the concrete proportions and the size of each batch. In addition to the actual mixing time, it will be necessary to allow for delays, shutdowns, etc., as maximum output cannot be figured for the entire job, as the men must be paid for time getting ready to start work in the morning, cleaning and washing wheelbarrows and concrete mixer at noon and at night; cutting and removing old concrete drippings and spillage; building and removing runways; delays caused by non-delivery of materials, etc.

Based on an average of 14 cu. yds. of concrete an hr. it will require 25 to 28 men in the gang, distributed as follows: 6 laborers loading and wheeling gravel or crushed stone; 3 laborers wheeling sand; 1 or 2 laborers on cement; 1 laborer feeding mixer; 1 laborer dumping concrete from mixer into wheelbarrows or buggies; 5 to 7 laborers wheeling concrete from mixer to place of deposit, depending upon length of haul; 3 to 4 laborers dumping concrete carts or barrows, spreading, spading and tamping concrete in place; 3 to 4 laborers general labor, such as building and removing runways, cleaning concrete mixer, wheelbarrows or buggies, picking up or baling cement sacks and other miscellaneous labor; 1 engineer on mixer and 1 mason or concrete foreman in charge of gang.

On the above basis, the labor per cu. yd. of concrete should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	2.0	$.....	$.....	$5.00	$10.00
Foreman	0.13*	.....	.....	5.25	.68*
Mixer engineer	0.13*	.....	.....	6.00	.78*
Cost per cu. yd.	2.26		$.....		$11.46

* Includes all lost time.

In many instances concrete will be placed for 65 to 75 percent of the above costs, but this will merely represent a day's run and not the average for the entire job.

Using a power buggy to transport the concrete from the mixer or hopper to place of deposit, one or two power buggies should handle all the concrete a 16-S mixer can turn out. This will eliminate 3 to 4 laborers wheeling concrete and result in a saving of ¼ to ⅓-hr. per cu. yd. of concrete.

Mixing Concrete in a 28-S (1 Cu. Yd.) Mixer.—If the concrete is mixed in a 28-S mixer, fed by wheelbarrows and the concrete wheeled from the mixer to place of deposit the labor costs per

cu. yd. will run approximately the same as given for 16-S mixers, under similar conditions.

While it is true the daily output will be greatly increased, the labor cost feeding the mixer and distributing the concrete will be increased in proportion.

Estimating the Cost of One Cu. Yd. of Concrete.—To illustrate the various items that make up the cost of a cu. yd. of concrete (exclusive of wood forms or reinforcing steel), estimate the cost of a cu. yd. of concrete mixed in the proportions of 1:3:5, using 1" stone and under the labor cost based on using a 6-S (1-sack) mixer, and wheeling concrete from mixer to place of deposit.

	Hours	Rate	Total	Rate	Total
4.58 sacks portland cement..		$.....	$.....	$1.80	$ 8.24
0.51 cu. yds. sand		.....	.....	4.05	2.07
0.85 cu. yds. gravel		.....	.....	4.05	3.44
Labor	2.50	.....	.....	5.00	12.50
Foreman	0.17	.....	.....	5.25	.89
Cost per cu. yd.	2.67		$.....		$27.14
Material cost per cu. yd.....			.....		13.75
Labor cost per cu. yd.....			.....		13.39

The above represents the actual cu. yd. cost of material and labor but does not include equipment charges, trucking on equipment, insurance, social security, unemployment compensation, or contractors' overhead expense and profit.

Labor Mixing and Placing One Cu. Yd. of Concrete for Foundations

Method of Mixing and Placing	Hours per Cubic Yard: Common Labor	Mixer Engr.	Hoist. Engr.	Foreman
Hand mixing using one mixing board	3.33*	..	..	0.33
Hand mixing using two mixing boards.....	3**	..	..	0.25
Using one sack (6-S) mixer and wheeling to place	2.5†	..	..	0.17
Using two sack (11-S) mixer and wheeling to place.....	2	0.125	..	0.125
Using 16-S mixer and wheeling to place	2	0.125	..	0.125
Using 28-S mixer and wheeling to place	2	0.083	..	0.08
Using conveyors, batcherplant, hoist and wheeling to place....	1.25	0.06	0.06	0.06

(See following page for footnotes.)

Above time includes all lost time in connection with concrete foundations.

Add for labor erecting and dismantling hoisting towers, spouts, hoisting engines, mixers, etc., as this may vary from $500.00 to $5,000.00, depending upon size of job.

If power buggies are used for wheeling concrete from mixer or receiving hopper to place of deposit, it will usually result in a saving of ¼ to ⅓-hr. per cu. yd. of concrete.

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*In extreme warm weather or southern states, add ½ to ⅔-hr.

**If necessary to load concrete into barrows and wheel from mixing board to place of deposit, add ½ to ¾ hr. per cu. yd.

†Under extremely favorable conditions, this may be reduced ¼ to ½-hr.

Loading Mixer Using a Tractor Shovel

During these days of high labor costs many new methods are being used to reduce costs.

One method employs a tractor shovel to load the sand and gravel from the stock piles and dump it into the loading skip at the mixer. This eliminates the men loading wheelbarrows with sand and gravel by hand, but there is usually one man necessary on the stock pile, plus the small Tractor shovel and operator. When supplying a 6-S mixer, it would eliminate about 5 men loading and wheeling sand and gravel but would add one man for the stock piles, plus the tractor shovel and operator.

When supplying a 16-S mixer with a tractor shovel, it would eliminate about 9 men loading and wheeling sand and gravel but would add 1 man on the sand stock pile; 1 man on the gravel stock pile, plus the tractor shovel and operator.

When supplying a 11-S mixer in this manner, it would eliminate 6 to 7 men loading and wheeling sand and gravel but would add 1 man on the stock piles, plus the tractor shovel and operator.

Mixing and Placing Concrete Where Materials Are Delivered to Job Batch Proportioned.—Another method of handling concrete work is to have the concrete aggregates delivered to the job in trucks, correctly proportioned for one batch of concrete, including cement, sand and gravel or crushed stone.

When this method is used, the concrete aggregates for each batch are proportioned in the material yard and delivered to the job ready to mix. The truck backs up to the mixer and discharges the cement, sand and gravel or crushed stone into the loading hopper. A paving mixer with a large, flat loading hopper is commonly used for this purpose as it facilitates dumping the aggregates from the trucks into the loading hopper.

This method eliminates the necessity of all men loading and

wheeling cement, sand and coarse aggregates, and the time required per cu. yd. of concrete should average as given in the following table.

Labor Mixing and Placing One Cu. Yd. of Concrete for Foundations When Aggregates Are Yard Proportioned and Delivered to the Job a Batch to a Load

	Hours per Cubic Yard			
Method of Mixing and Placing	Common Labor	Mixer Engr.	Hoist. Engr.	Foreman
16-S mixer and wheeling to place.	1.25	0.125	..	0.125
28-S mixer and wheeling to place.	1.25	0.083	..	0.083

If power buggies are used for wheeling concrete from mixer to place of deposit, it will usually result in a saving of ¼ to ⅓-hr. labor time per cu. yd. of concrete.

Above includes all lost time in connection with mixing and placing concrete.

Add for labor erecting and dismantling hoisting towers, hoisting engines, mixers, etc., as this may vary from $500.00 to $5,000.00, depending upon size of job.

Ready-Mixed Concrete

When using ready-mixed concrete, all labor in connection with operating the concrete mixer, unloading and handling materials, supplying the mixer with sand, gravel and cement is eliminated, as the trucks dump the ready-mixed concrete directly into the forms or into a hopper from where it is distributed by wheelbarrows, concrete buggies or hoisted.

If the concrete is not deposited direct from the truck mixer into the forms it is necessary to have a fairly large hopper on the job to receive the concrete from the trucks because the hoisting buckets, wheelbarrows or concrete buggies must be supplied from this hopper. The same amount of labor will be required building and removing runways, cleaning concrete hoppers, buckets, wheelbarrows and buggies as when the concrete is job mixed, so the only labor saved is in connection with the concrete aggregates and operating the mixer.

The labor handling and placing ready mixed concrete will vary somewhat with the quantity handled and placed per day as the same number of foremen, hoisting engineers, etc., will be required whether 50 or 300 cu. yds. of concrete are placed per day. The method of distributing the concrete, whether wheelbarrows or concrete buggies will also affect the labor costs

Labor Placing One Cu. Yd. of Ready-Mixed Concrete for Concrete Foundations

Method and Quantity Placed per 8-Hr. Day	Hours per Cubic Yard: Common Labor	Hoisting Engineer	Foreman
Placing concrete directly in forms, 1 truck servicing job, 50 to 70 cu. yds..	0.35-0.50	....	0.13
Placing concrete directly in forms, 2 trucks servicing job, 100 to 150 cu. yds	0.27-0.40	....	0.08
Using wheelbarrows, 50 to 70 cu. yds...	1.25-1.50	0.17*	0.17**
Using wheelbarrows, 100 cu. yds. and over	1.00-1.25	0.13*	0.13**
Using concrete buggies, 50 to 70 cu. yds.	1.00-1.25	0.17*	0.17**
Using concrete buggies, 100 cu. yds and over	0.90-1.10	0.13*	0.13**
Using 13 cu. ft. power concrete buggies.	0.65-0.75	0.13*	0.13**

*Where the concrete is hoisted and it is necessary to use a hoisting engineer, add as given in table.

**If union regulations require a mason or cement finisher foreman in charge of crew, add as given in table.

If power buggies are used for wheeling concrete from mixer or hopper to place of deposit, it will usually result in a saving of ¼ to ⅓ hr. labor time per cu. yd. of concrete.

Add for labor erecting and dismantling hoisting towers, etc., as this may run from $500.00 to $5,000.00 depending upon the size of the job.

Placing Concrete with a Crane and Bucket.—In recent years the crane and bucket has become ever increasingly popular on large jobs as a means for transporting mixed concrete from the mixer or ready-mix truck to the forms, thereby eliminating the necessity of building and removing runways, labor wheeling concrete, etc. This is especially true when the crane and bucket is used in conjunction with ready-mixed concrete as the amount of labor is reduced to a minimum. (Refer to Table on following page.)

Cold Weather Concreting

During the late fall and early spring and during all of the winter months it is necessary to use special precautions to assure proper hardening of the concrete. Careful contractors will use protection whenever the temperature falls below 50° F. At such times the most important protection required is to heat the sand and mixing water.

During freezing weather an extra boiler (old hoisting engine boiler, for example) having a rating of 25 to 50 Hp. according to

Labor Placing One Cu. Yd. of Foundation Concrete Using Crane and Bucket

Method Mixed	Quantity Placed per 8-Hr. Day cu. yds.	Hours per Cu. Yd. Common Labor	Crane Operator	Mixer Engineer	Iron Worker*	For ma
16-S mixer, batched material	70 to 90	.70	.10	.10	.10	
28-S mixer, batched material	150 to 170	.50	.05	.05	.05	.(
Ready-mix	150 to 170	.40	.05	...	.05	.(

Add for equipment cost or rental of crane and bucket.

*Add only if required.

the size of the job (10,000 to 25,000 sq. ft. floor area) with steam gauge set for 2 or more lbs. pressure per sq. in. will b needed with at least 2 perforated pipes for heating the coars aggregate in addition to that required for heating the sand. O larger jobs or for fast concreting where aggregate bins are use a grillage of steam pipes 4'-0" apart at the bottom of the bi will be sufficient. These pipes should have ¼" perforations abou 4" on centers. A 1½" steam line should be run from the boile to the water tank and another line run up the side of the build ing with valves and connections for steam hose to be used fo cleaning out ice and snow.

Sufficient steam should be available so the concrete has a tem perature of 50 to 70 degrees when leaving the mixer. This wi promote the setting of the cement and permit earlier remov of the forms.

On small jobs the flame of an oil heater is allowed to proje into the mixer to heat the materials.

Footings are generally protected by covering the fresh con crete with 8" to 12" of marsh hay or straw and with tarpauli or old bags thrown over the hay.

Figure ½ to ¾ hr. labor time per cu. yd. of concrete and on bale (80 lbs.) of loose hay or straw per 100 sq. ft. to be covere

Foundation walls should be protected in mild weather by cov ering the top of the wall with hay and the sides of the form with tarpaulins. During more severe weather place coke or o burning salamanders every 30 to 40 ft. apart and cover wit tarpaulins; care being taken to keep the tarpaulins sufficien distance from the closed salamanders.

A good method of melting frost between the concrete an

forms before removal of the forms, is to let hot water run for a few hours from a 1" perforated pipe placed on top of the concrete wall. It will find its way between the forms and concrete and melt the ice, making form removal much easier.

In skeleton construction it will be necessary to curtain the walls with tarpaulins for the story being concreted and in very severe weather it may be necessary to curtain two stories with tarpaulins, and to cover the top floor with hay or straw, held down by planks or timbers, which in turn support a layer of boards and planks with tarpaulins thrown over them. Stair and elevator openings, and openings for steam and plumbing pipes will allow heat to penetrate beneath the protecting layers and to heat the top of the floor.

It will require one salamander for each 200 to 250 sq. ft. of floor surface according to the severity of the weather and sufficient fuel should be placed on the floor in the early afternoon to last until next morning. Heat should be supplied for 2 to 5 days or more depending upon whether high-early-strength or normal portland cement is used and on the temperature maintained. Barrels of water should be placed on each floor for fire protection.

Unloading Concrete Materials from Cars

Where concrete materials are delivered to the job in cars, the following unloading costs will assist the estimator.

Unloading Sand from Cars by Hand.—This cost will vary with the size of the shovel used, but a laborer should shovel and throw out of cars 10 to 14 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.67	$.....	$.....	$5.00	$3.35

If sand freezes in the cars it is practically impossible to loosen it and unless steam is used overnight to thaw the material, the labor costs will run 4 to 5 times of those given above.

If a gasoline powered car unloader is used for unloading hopper cars, they can be unloaded at the rate of about 2 cu. yds. or 6,000 lbs. a minute when operating at capacity. If the material is to be stock piled, a portable conveyor would be required to convey the materials from car unloader to stock pile.

Unloading Gravel from Cars by Hand.—It is a trifle more difficult shoveling gravel than sand, but a laborer should shovel and throw out of cars 10 to 12 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.75	$.....	$.....	$5.00	$3.75

If gravel freezes in the cars it is practically impossible to loosen it and the labor costs will run 4 to 5 times those given above; unless steam is used overnight to thaw the material.

If a gasoline powered car unloader is used for unloading hopper cars, they can be unloaded at the rate of about 2 cu. yds. or 6,000 lbs. a minute when operating at capacity. If the material is to be stock piled, a portable conveyor would be required to convey the materials from car unloader to stock pile.

Unloading Crushed Stone from Cars.—On account of the sharp edges on crushed stone, it is harder shoveling than either sand or gravel, but a laborer should shovel and throw out of cars 8 to 10 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.88	$.....	$.....	$5.00	$4.40

Unloading Sand and Gravel from Cars by Crane.—When large quantities of sand and gravel must be unloaded continuously from flat bottom gondola cars, in order to keep a job supplied with concrete materials, a crane equipped with a rehandler clamshell bucket is usually chosen for the operation. Using this method of unloading, the material may either be stockpiled or deposited into the bins of a batcher plant.

A crane equipped with a ½ cu. yd. capacity rehandler clamshell bucket, unloading from a flat bottom gondola to the bins of a batcher plant with an average swing of 140° should unload 25 to 35 cu. yds. of sand or gravel per hour or 200 to 280 cu. yds. per 8-hr. day. One laborer is usually kept in the car for the full time to give signals to the crane operator, to guide the clamshell bucket to pick up maximum loads and to shovel material from the corners of the car to where it may be picked up by the "clam."

The preceding production takes into account time lost due to moving cars into position for unloading and is based on the assumption that no delays are experienced from switching operations, lack of loaded cars or freezing conditions.

This work should be done at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Crane operator	0.033	$.....	$.....	$6.75	$0.223
Labor	0.033	.....	.....	5.00	0.165
Cost per cu. yd.	0.066		$.....		$0.388

Using a crane equipped with a one cu. yd. capacity rehandler clamshell bucket, under the same conditions as above, 50 to 70 cu. yds. of sand or gravel should be unloaded per hour at the following labor cost per cu. yd.;

	Hours	Rate	Total	Rate	Total
Crane Operator	0.017	$.....	$.....	$6.75	$0.115
Labor	0.017	.....	.....	5.00	0.085
Cost per cu. yd.,...	0.034		$.....		$0.200

If the material may be stockpiled instead of discharged into batcher plant bins, above costs may be reduced 20 to 25 percent.

If the material to be unloaded is crushed stone, add 5 to 10 per cent to the above costs.

To the above costs must be added a charge for moving cars into position and equipment cost or rental of crane and clamshell bucket.

Unloading Cement from Cars.—This cost will vary with the distance of the cars or trucks from the shed, the height to which it must be piled, and whether or not it is to be counted by the men unloading.

If the piles are not over 5′-0″ high and it is not necessary to count the bags, 3 men working together should unload and pile 800 bags (200 bbls.) per 8-hr. day, at the following labor cost per bbl.:

	Hours	Rate	Total	Rate	Total
Labor	0.13	$.....	$.....	$5.00	$0.650

If a small power buggy or truck is used for hauling the cement from the cars or trucks to the storage shed, the hauling time would be reduced but not the loading, unloading and stacking time.

Reduce the above costs about 10 percent if a power buggy or truck is used for this purpose.

If the cement must be counted by the men unloading, wheeled to shed and placed in piles 9′-0″ to 10′-0″ high, it will require 4 men 8 hrs. each to unload, count and stack 800 bags (200 bbls.), at the following labor cost per bbl.:

	Hours	Rate	Total	Rate	Total
Labor	0.167	$.....	$.....	$5.00	$0.835

If the cement is unloaded from cars to trucks, a laborer should unload 400 bags (100 bbls.) of cement per 8-hr. day, at the following labor cost per bbl.:

	Hours	Rate	Total	Rate	Total
Labor	0.08	$.....	$.....	$5.00	$0.400

Unloading Lumber from Cars.—Where the form lumber is shipped to the job in cars, a laborer should unload, carry and pile 3,250 to 3,750 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft. b.m.:

	Hours	Rate	Total	Rate	Total
Labor	2.3	$.....	$.....	$5.00	$11.50

If the lumber is unloaded from cars to trucks, a laborer should unload 4,750 to 5,250 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft. b.m.:

	Hours	Rate	Total	Rate	Total
Labor	1.6	$.....	$.....	$5.00	$8.00

A truck will carry 3,500 to 8,000 ft. b.m. per load.

CHAPTER VIII

REINFORCED AND ARCHITECTURAL CONCRETE

Reinforced and architectural concrete are among our most common building materials and are used on practically all classes of construction work.

They are used in all types of structures, from residential, apartment, hotel and hospital buildings, requiring comparatively light floor loads, to the heaviest constructed warehouses, factory buildings, wharves, industrial buildings, etc.

In fact, entire buildings are constructed of concrete, including ornamental exterior walls, floors, all structural supporting members, etc.

Because of its flexibility, it is used in a number of ways and in conjunction with clay tile, metal pans, concrete soffitile or it may be used alone in the construction of floors, roofs and all types of skeleton buildings.

Regardless of the fact that it is one of our most common building materials, costs on all classes of reinforced concrete construction are subject to wide variation. This is due to a number of causes, such as the type and size of building, whether flat slab or beam and girder type; whether solid concrete construction or used in conjunction with clay tile, concrete or metal pans, local conditions, etc.

The methods used in erecting and moving the formwork, handling, mixing and placing the concrete, and last but not least, the ability of the superintendent or foreman, all affect the final costs of the work.

Regardless of how carefully or accurately the job has been estimated, if the superintendent or foreman in charge of the work are not proficient, the actual costs are almost certain to run higher than the estimate—not because the work was estimated too low but because it was poorly handled on the job.

All labor costs given on the following pages are based on efficient management; economical layout and design of all formwork; use of modern labor-saving methods, such as bench fabrication of column, beam and girder forms where possible, and the use of labor saving tools such as power saws, band

saws, electric hand saws, etc. For instance, an electric hand saw will cut off a 2″x12″ plank in 4 seconds where it requires about a minute by hand. It takes about 9 minutes by hand to rip a 12′-0″ plank 2″ thick but it takes only 40 to 45 seconds using an electric saw. These are just a few of the savings that can be made by using labor-saving tools and equipment.

In these days of high wage scales, the efficient contractor must use methods and tools that will reduce costs to a minimum, or else he may be out of the running when it comes to obtaining work in competition and of performing it economically after he has obtained the job. Remember, good management, economical design, labor-saving tools and methods are absolutely necessary to a profitable contract.

Items to be Included in the Estimate.—Reinforced concrete should be estimated in the same manner and in the same units as the work is constructed on the job. This allows comparisons between estimated and actual costs and enables a contractor to tell where variations occur between estimated and actual costs.

The first operation on any reinforced concrete job is the erection of the temporary wood or metal forms to support the weight of the wet concrete until it has set sufficiently to be self-supporting. The members usually requiring forms are the columns, girders, beams, spandrel beams, lintels, floor slabs, stairs and platforms. Each class of formwork should be estimated separately and in detail as described on the following pages.

All types of form work, including columns, beams, girders and the various type of floor slabs have been designed in the best engineering practice, giving lumber requirements, clamp spacing for columns, beam and girder lumber requirements, including shoring, together with a complete set of design tables for all types of concrete floor slabs, giving joist spacing, spans of stringers and shores required for any floor load.

After the forms are erected, it is necessary to place the reinforcing steel or wire mesh ready to receive the concrete. This may include unloading steel from cars or trucks at the job, cutting steel to length and bending to special shapes for columns, beams, girders and floor slabs, and placing it in position ready to receive the concrete.

After the reinforcing steel is in place, the job is then ready for concrete. This consists of preparing runways, unloading cement and other materials; mixing the cement, sand and gravel into the concrete mass, hoisting, wheeling and placing it in position; removing runways, removing old concrete drippings

and spillage, patching, cleaning and washing wheelbarrows or buggies, concrete mixer, etc.

Each of these items should be estimated in detail to include all material and labor operations necessary to make up the completed unit.

FORMS FOR REINFORCED CONCRETE

Concrete Column Forms.

Reinforced concrete columns may be either square, rectangular, octagonal or round in shape. The forms for square or octagonal columns are usually constructed of wood while metal or fiber molds are used for round columns.

The wood forms may be constructed of either 1" or 2" lumber, although 1" lumber is commonly used. While 2" lumber has greater salvage value the original cost is twice as much and the labor required to handle and wreck 2" lumber is much greater than for 1" lumber, which accounts for the greater use of 1" material.

Where an exceptionally smooth finish is required on the columns, plywood may be used instead of wood sheathing.

Forms for reinforced concrete columns should be estimated by the sq. ft. obtained by multiplying the girth of the column by the height. Example: obtain the number of sq. ft. of forms in a column 18" square and 12'-0" high. Proceed as follows: 18+18+18+18=72" or 6'-0", the girth. Multiply the girth by the height, 6'-0"x12'-0"=72 sq. ft. of forms.

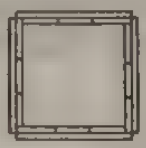
The forms for all square or rectangular columns should be estimated in this manner.

To prevent the column forms from spreading while the concrete is placed and until it hardens, wood or metal clamps should be run around the column at intervals, depending upon the height of the column.

In recent years the use of wood clamps has been almost entirely eliminated by the use of metal clamps.

The pressure of the fresh concrete has a greater effect on the design of column forms than on wall forms on account of the smaller amount of concrete to be placed. The contractor usually finds it more convenient and economical to fill a group of medium size columns in as short time as possible, perhaps 30 minutes, when the full liquid pressure of the fresh concrete will be acting: namely, 150 lbs. per sq. ft. for every foot in depth of the concrete. But even when concreting is proceeding at a slower rate, the richer concrete which is commonly used for columns (say 1:1.5:2.5 and of a slump of perhaps 6") will exert a maximum pressure of 1,000 lbs. per sq. ft. at 60° F., when the

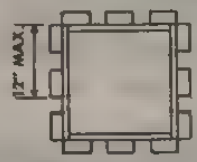
TYPE A



7/8" sheathing with horizontal 1 x 4 cleats.

Height of column in feet	STORY HEIGHTS 10	12	14	16	18	20
	32	32	32	32	32	32
	20	20	20	20	20	20
	16	16	16	16	16	16
	13	13	13	13	13	13
	13	13	13	13	13	13
	12	12	12	12	12	12
10	8 6	12	12	12	12	12
		12	12	12	12	12
12		8 6	11	11	11	11
			11	11	11	11
14			10 6	10	10	10
				10	10	10
16				8 6 6	10	10
					9	9
18					9 6	9 8
						8
20						8 6

TYPE B



3/4" plywood with vertical 2 x 4 cleats.

Height of column in feet	STORY HEIGHTS 10	12	14	16	18	20
	33	33	33	33	33	33
	27	27	27	27	27	27
	24	24	24	24	24	24
	21	21	21	21	21	21
	9					
10	6	20	20	20	20	20
		13 6	19	19	19	19
12			18 6	18	18	18
14				15 9 6	17	17
16					16	16
					15 6	15 12
18						12 6
20						

Each horizontal line represents a column clamp and numbers between lines indicate suggested spacing in inches.

Column Clamp Spacing, in Inches, Based on Strength of Materials and Limited by 1/8" Deflection.

rate of concreting is only 4'-0" per hour, while as was shown in the case of concrete wall forms, a mixture of 1:2.5:3.5 concrete at 60° F. exerts a maximum pressure of only 800 lbs. per

sq. ft. when concreting proceeds at a rate of 10′-0″ per hr.

Only in columns of less than 20″ to 24″ in size, is it generally economical to have the full liquid pressure exerted on the entire height of the column forms. In this instance, the spacing of the yokes or clamps cannot exceed the distances shown in the accompanying illustration. These distances depend upon the strength of the ¾″ boards of the column forms, which are assumed to be in one length for the entire height of the column. Where there is a splice or joint of the boards at a yoke, the distance between the yokes must be reduced 20 percent on each side of the joint.

Column Form Design

Sheathing boards are usually furnished 3⅝″, 5⅝″, 7½″, 9½″ and 11½″ wide for square edge stock, and 3¼″ and 5¼″ wide for D&M stock. Using square edge stock, two 7½″ boards easily make a column side 15″ wide but when the architect or engineer calls for a column 16″ wide, it is necessary to rip 1″ off a 9½″ board, which together with a 7½″ board makes a column side 16″ wide. This refers to the narrow side of the column form only. For the wider side of the form it is necessary to use a 7½″ and a 9½″, making a total width of 17″.

Deducting the width of the two ¾″ narrow column form sides leaves an actual concrete surface of 17″—1½″=15½″. If the architect or engineer does not accept this width it will be necessary to rip 1½″ off a 9½″ board. This impractical method of designing column sizes is quite common and increases both labor costs and superintendence.

The column form sides should be made on a bench in a jig; uniting the boards with 1″x4″ or 1″x6″ cleats in distances of less than 3 ft. and drawn tightly together with carpenters' clamps.

There are two principal methods of erecting column forms; one is to unite all the four sides on two or three horses near the site where the form is to be erected and have 4 or 6 laborers hoist the complete form over the column dowels and stand it up temporarily; or in case of heavier columns, a simple 4″x6″ pole derrick may be used for erection. Sometimes 3 sides of the column form are united and shoved into place without lifting the heavy box over the dowels, while the other and decidedly more expensive method is to erect each column form side separately.

As an example of the lumber required for a column form, take a concrete column 20″ square and 11′-0″ high underneath the lowest beam, and assuming a full liquid pressure of 150 lbs. per

cu. ft. acting for the entire height of the column. It will require for each of the shorter sides 2 boards 7½" wide and 1 board 5½" wide and for the wider form sides, 3 boards 7½" wide. Assume the clear story height as 12'-6". The area of the column form as usually taken off by the estimator will be 4 sides x 1.667 x 12'-6" high equals 83.33 sq. ft.

Using steel column clamps the following lumber would be required for a 20"x20" concrete column form 12'-6" high.

	Feet, B.M.
10 pcs. ¾"x7½"-14'-0"	94
2 pcs. ¾"x5½"-14'-0"	14
20 pcs. 1"x6"-1'-9" cleats	18
Lumber required for 83.33 sq. ft. forms	126
Lumber required per sq. ft.	1.5
Bracing lumber per sq. ft. forms	0.6
Total lumber required per sq. ft. forms	2.1

In order to brace the column form and hold it plumb until the deck or floor forms are erected and braced, it will require 4 pcs. 2"x4"-16'-0" to 20'-0" long, which will add another 48 ft. b.m. to the lumber required. This bracing lumber may be used at least 3 or 4 times and eventually, for other purposes than column forms. Bracing lumber is included in the above table.

The number of steel column clamps required may be somewhat larger than usually recommended by the manufacturers depending upon the speed with which the column forms are filled. The spacing in the lower part of the column should be about 9"; about 1'-0" near the middle and the first three spacings from the top should be 1'-3" to 1'-8" apart.

An average of one clamp per foot of column height will be safe in this particular instance.

Such clamps may be rented from the manufacturers for 30 to 50 cts. per month, f.o.b. shop, to which is added freight and trucking to and from the job, which may amount to another 10 cts. or more. The cost will be 35+7½+7½=50 cts. if the clamps are used for only one month. If used 4 times, 50÷4=12½ cts. each use.

If rich concrete is poured into the column form at the rate of only 4'-0" an hour, then the highest pressure which will be exerted per sq. ft. of forms in the lower 4'-0" will be only 1,000 lbs. and may save the use of 2 clamps on the whole column form; the money value of which is much less than the expense of repeatedly starting and stopping the concrete operations on the columns.

When plywood is specified for the same 20″ column forms, the following lumber will be required:

	Sq. Ft.
2 pcs. ¾″ plywood, 1′-9½″x8′-0″	32
2 pcs. ¾″ plywood, 1′-9½″x4′-6″	18
2 pcs. ¾″ plywood, 1′-8″x8′-0″	32
2 pcs. ¾″ plywood, 1′-8″x4′-6″	18
Total plywood required for 83 sq. ft. of forms	100

Inasmuch as plywood is furnished in panels 4′-0″ wide and 8′-0″ long, there is considerable waste unless columns are of sizes that will cut from the plywood sheets without waste, which is unusual.

Plywood will require about 15 percent closer spacing of clamps than ¾″ sheathing, some wooden cleats to hold the forms square for erection, and the same amount of bracing, so the total lumber requirements for a 20″ column using ¾″ plywood sheathing and 1x4 horizontal cleats would be as follows:

	Feet, B.M.
Plywood sheathing	100
Cleats	18
Bracing	48
Lumber required for 83⅓ sq. ft. forms	166
Lumber per sq. ft. of forms	2.0

Another method of stiffening plywood column form panels is by using 2″x4″ vertical cleats. This method permits greater spacing of clamps as shown in the table and the total lumber requirements for a 20″ column using ¾″ plywood sheathing and 2″x4″ vertical cleats would be as follows:

	Feet, B.M.
Plywood sheathing	100
Cleats	112
Bracing	48
Lumber required for 83⅓ sq. ft. forms	260
Lumber per sq. ft. of forms	3.1

Octagonal columns are seldom used on account of the expense of the wood forms, but occasionally where machinery is to be fastened to the columns, it is necessary to use them.

It makes little difference in the labor cost whether an octagonal column is 18″ or 24″ in diameter, as both require about the same amount of labor in their construction, so it is advisable to estimate the cost of these forms at a certain price per column, instead of by the sq. ft. This cost should be computed on the average size of the columns, and then multiply by the number of columns in the job.

When round concrete columns are used, metal or fibre molds

PRACTICAL
MFD IN U.S.A.
Form 116

GENERAL ESTIMATE

BUILDING Clark Street Garage
LOCATION Chicago
ARCHITECTS W C Walker
SUBJECT Reinforced Concrete

ESTIMATE No. 215
SHEET No. 4
ESTIMATOR EFZ
CHECKER JMB.
DATE March 15, --

DESCRIPTION OF WORK	NO. PIECES	DIMENSIONS L	W	D	FRANK B WALKER CO., PUBLISHERS, CHICAGO EXTENSIONS	EXTENSIONS	TOTAL ESTIMATED QUANTITY	UNIT PRICE MTL	TOTAL ESTIMATED MATERIAL COST	UNIT PRICE LABOR	TOTAL ESTIMATED LABOR COST
Columns – 3,000-lb Ready-Mix					Concrete	Forms					
1st story	1 F4S	1-6	1-6	12-0	27	72	Sq Ft Forms				
	4 F4S	1-8	1-8	12-0	133	320	968	10	97	48	465
	6 F4S	2-0	2-0	12-0	288	576	Cu Yds Conc				
					448	968	16 2/3	13.00	217	3.50	58
Beams & Girders – 3,000-lb Ready-Mix											
	1 F3S	18-0	1-0	1-6	27	72	Sq Ft Forms				
	2 F3S	12-0	0-8	1-0	16	64	486	13	63	50	243
	5 F3S	14-0	1-0	2-0	140	350	Cu Yds Conc				
					183	486	6 1/5	13.00	88	3.00	20
Floor Slabs – 3,000-lb Ready-Mix							Sq Ft Forms				
	F	20-0	16-0	0-8	213	320	536	11	59	32	172
	F	18-0	12-0	0-6	108	216	Cu Yds Conc				
					321	536	12	13.00	156	3.00	36

Method of Measuring Plans and Listing Quantities for Reinforced Concrete Construction.

are used for supporting the wet concrete until it has "set." Some columns consist of a straight shaft extending from floor to ceiling, while others have a cone head at the top of the column. The forms for round concrete columns should be estimated at a certain price per column, stating whether columns have plain shafts or cone heads, as it costs considerably more to erect the latter. There are several concerns in the country who make a specialty of renting and erecting these column molds complete and will quote a lump sum price on the job.

An easy method of listing the concrete columns and forms from the plans at one operation is to list the number of columns, dimensions, length, etc., then at the side of the column headed "No. Pcs." place in small letters "F4S," which designates that the column requires "Forms 4 sides," so when extending the quantities on the estimate sheet, the quantity of concrete can be extended in cu. ft. and the quantity of forms listed in sq. ft. See illustration of estimate sheet on previous page showing the method suggested for easy, accurate estimating.

Labor Cost of Wood Forms for Square Concrete Columns.—The labor cost of wood forms for square or rectangular concrete columns will average about the same regardless of the type of building, but the variations are due to the method used in assembling and building-up the column sections, their size, method of clamping, etc.

On jobs of any size it is customary to have a mill on the job, where the column forms are built to exact size, including cut-outs for beams or girders, and then sent to the floor on which they are to be used, ready for erection.

If 1" sheathing is used with steel column clamps it will require about 2.1 ft. b.m. per sq. ft. of forms.

The following labor costs are based on a certain number of man hours per 100 sq. ft. of forms, regardless of whether the work is performed by carpenters or whether laborers carry and handle the lumber ready for the carpenters, so the estimator must use his own judgment as to the class of labor to be used on each job estimated.

On this basis a carpenter would handle, frame and erect 175 to 225 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	40	$.....	$.....	$6.75	$270.00
Labor	20	.....	.....	5.00	100.00
Cost per 1,000 ft. b.m...	60		$.....		$370.00

A laborer should remove 750 to 950 ft. b.m. of column form

lumber per 8-hr. day, at the following labor cost per 1,000 ft. b.m.:

	Hours	Rate	Total	Rate	Total
Labor	9.5	$.....	$.....	$5.00	$ 47.50

Here is an important item when figuring column form costs. How many times can they be used on the job without cutting down or extending their length or must they be reworked and cut down for each floor? This is a matter each estimator or contractor must decide for himself from a study of the plans and for this reason costs are given on making up the column forms and separate labor costs covering the erection.

Cost of 100 Sq. Ft. Square Concrete Column Forms, Using Adjustable Steel Clamps

Material Required	Hours	Rate	Total	Rate	Total
210 ft. lumber		$.....	$.....	$ .06*	$ 12.60*
Rental 14 column clamps		.....	.....	.07†	.98†
Making Forms					
Carpenter	3.0	.....	.....	6.75	20.25
Labor helping	1.5	.....	.....	5.00	7.50
Assembling, Erecting, Plumbing and Bracing					
Carpenter	6.0	.....	.....	6.75	40.50
Labor helping	3.0	.....	.....	5.00	15.00
Removing Clamps and Forms					
Labor	2.0	.....	.....	5.00	10.00
Cost per 100 sq. ft.	15.5		$.....		$106.83
Cost per sq. ft.			.....		1.068
Material cost per sq. ft.			.....		.136
Labor cost per sq. ft.			.....		.932

For erecting, plumbing and bracing outside column forms, increase labor costs 10 percent.

Cost of 100 Sq. Ft. Concrete Column Forms, Using Plywood Sheathing with Adjustable Steel Clamps and 1"x4" Horizontal Cleats

Material Required	Hours	Rate	Total	Rate	Total
66 ft. lumber cleats and bracing		$.....	$.....	$0.06*	$ 3.96*
120 Sq. ft. ¾" plywood		.....	.....	.12*	14.40
Form coating		.....	.....	.01	1.00
Rental 16 column clamps		.....	.....	.07†	1.12†
Carried Forward					$20.48

*Lumber cost based on using each set of forms 3 times. If same forms may be reused without working over and cutting down, omit "Labor Making Forms" after first use.

†Based on 6 uses of clamps per month.

	Hours	Rate	Total	Rate	Total
Brought Forward					$ 20.48
Making Forms					
Carpenter	3.0	$.....	$.....	$6.75	20.25
Labor	1.5	.....	.....	5.00	7.50
Assembling, Erecting, Plumbing and Bracing					
Carpenter	6.0	.....	.....	6.75	40.50
Labor helping	3.0	.....	.....	5.00	15.00
Removing Clamps and Forms					
Labor	2.0	.....	.....	5.00	10.00
Cost per 100 sq. ft.	15.5		$.....		$113.73
Cost per sq. ft.			.....		1.137
Material cost per sq. ft.			.....		.205
Labor cost per sq. ft.			.....		.932

Cost of 100 Sq. Ft. Concrete Column Forms Using Plywood Sheathing with Adjustable Steel Clamps and 2″x4″ Vertical Cleats

Material Required	Hours	Rate	Total	Rate	Total
120 sq. ft. ¾″ plywood		$.....	$.....	$0.12*	$ 14.40*
192 ft. lumber, cleats and bracing		.....	.....	.06*	11.52*
Form coating		.....	.....	.01	1.00
Rental 10 column clamps		.....	.....	.07†	.70†
Making Forms					
Carpenter	3.00	.....	.....	6.75	20.25
Labor	1.50	.....	.....	5.00	7.50
Assembling, Erecting, Plumbing and Bracing					
Carpenter	5.50	.....	.....	6.75	37.03
Labor helping	2.75	.....	.....	5.00	13.75
Removing Clamps and Forms					
Labor	2.00	.....	.....	5.00	10.00
Cost per 100 sq. ft.	14.75		$.....		$116.15
Cost per sq. ft.			.....		1.162
Material cost per sq. ft.			.....		.276
Labor cost per sq. ft.			.....		.886

*Lumber cost based on using each set of forms 3 times. If same forms may be reused without working over and cutting down, omit "Labor Making Forms" after first use.

†Based on 6 uses of clamps per month.

For erecting, plumbing and bracing outside column forms, increase labor costs 10 percent.

Octagonal Concrete Column Forms.—When estimating the quantities of octagonal concrete column forms, measure the entire girth of the column, the same as for square columns and multiply by the height. The result will be the number of sq. ft. of forms in each column.

When framing octagonal column forms, it does not make much difference whether each section is 6" or 8" wide, as the labor cost of framing will be about the same. For this reason the labor cost should be estimated at a certain price per column rather than by the sq. ft.

It will ordinarily require 14 to 16 hrs. carpenter time to frame and erect one octagonal column form, 1'-6" to 2'-0" in diameter and 12'-0" high.

Cost of Wood Forms for an Octagonal Concrete Column up to 1'-8" Diameter and 12'-0" High, Using Adjustable Metal Column Clamps

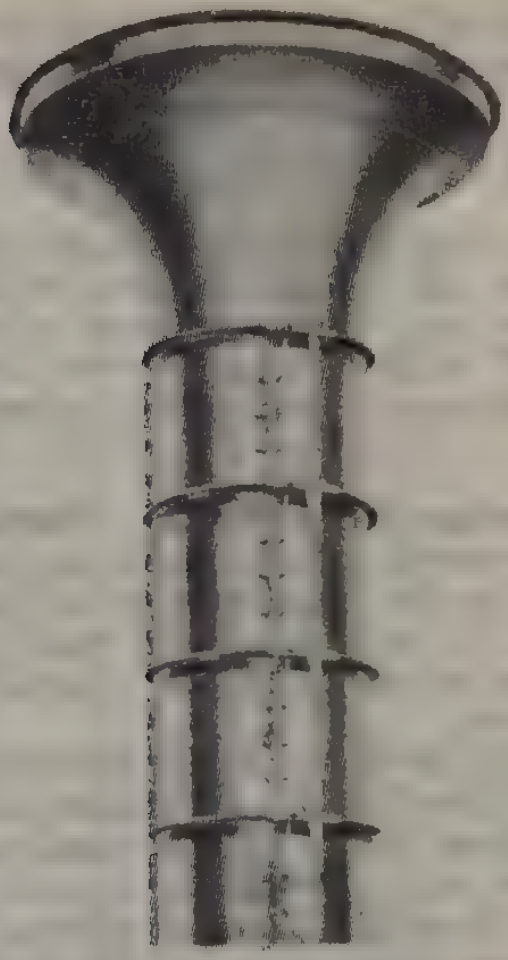
Material Required	Hours	Rate	Total	Rate	Total
267 ft. lumber		$.....	$.....	$0.06*	$ 16.02*
Rental 14 column clamps		.....	.....	.07†	.98†
Making Forms					
Carpenter	4.0	.....	.....	6.75	27.00
Labor helping	2.0	.....	.....	5.00	10.00
Assembling, Erecting, Plumbing and Bracing					
Carpenter	8.0	.....	.....	6.75	54.00
Labor helping	4.0	.....	.....	5.00	20.00
Removing Clamps and Forms					
Labor	2.5	.....	.....	5.00	12.50
Cost per column	20.5	.....	$.....		$140.50
Material cost per column			.....		1.405
Labor cost per column			.....		.170
					1.235

*Lumber cost based on using each set of forms 3 times. If same forms may be reused without working over and cutting down, omit "Labor Making Forms" after first use.

†Based on 6 uses of clamps per month.

Metal Forms for Round Columns

The cost of metal forms for round concrete columns will vary according to the diameter of the column, height, whether a plain shaft or one having a conical head, also whether it is necessary to cut out for beams and girders framing into the metal column molds.



Round Metal Column Molds

Where it is necesary to cut the metal molds or "heads" to frame into wood forms for concrete beams and girders, an extra labor allowance should be made.

The cost of this work will vary with the method used in erecting the columns. The average contractor sublets this work; including rental of the metal molds, erection and removal, at a certain price per column, based on the number of columns per floor and the number of stories in the building.

The time given on the following pages is based on using sheet metal workers experienced in erecting and removing metal column molds, because if green or inexperienced men are used the labor time may be doubled.

When plain round metal forms up to 24" in diameter are used without caps, which do not require cutting and fitting at head for concrete beams and girders, the labor erecting, removing and oiling one column mold should cost as follows:

	Hours	Rate	Total	Rate	Total
Sheet metal worker...	4	$.....	$.....	$7.00	$28.00

If the column has a conical head, necessitating placing a

metal cap in addition to the column shaft, the labor erecting removing and oiling one column should cost as follows:

	Hours	Rate	Total	Rate	Total
Sheet metal worker...	5	$.....	$.....	$7.00	$35.00

If necessary to cut and fit at column heads for concrete beams and girders, add 1 to 2 hrs. time per column.

The above labor costs are for columns up to 16'-0" in length For columns 16'-0" to 20'-0" long, add 1 to 2 hrs. time for sheet metal worker, because the higher the columns the higher the labor costs.

Leasing or Renting Metal Column Molds from the Manufacturers.—Where metal column molds are leased or rented by the manufacturer to the contractor to be used on a specified job and returned in good condition upon completion of the work, the following prices will prove a fair average for columns up to 24" in diameter.

For a plain metal mold for round concrete columns without cone head, figure $10 to $20 for each column in the job. The lower price is for jobs where the forms are reused five or six times.

For plain round metal forms for concrete columns having cone head, figure from $12 for each column on the job where the forms are reused about 5 times to $28 for each column where the forms are used once or twice.

For columns over 16'-0" high, add $1 per lin. ft. in height.

To the above prices add cartage from nearest railroad delivery point to job.

Metal Column Molds Erected in Place.—When sublet to a metal column contractor, the following erected prices will prevail unless unusual conditions are encountered.

Plain metal molds for columns up to 24" in diameter, without cone head, should cost as follows per column:

	Hours	Rate	Total	Rate	Total
Column mold rental*		$.....	$....	$18.00	$18.00
Sheet metal worker.....	4	.....	....	7.00	28.00
Cost per column.....	4		$.....		$46.00

For columns over 16'-0" high, add $1.00 per lin. ft.

Round concrete columns having a cone head should be figured as follows:

* Includes erection contractor's profit.

Cu. Ft. of Concrete in Flared Caps For Round Concrete Columns

Diam. of Col. Cap at Top	Diam. of Col. Cap at Bottom	Cu. Ft. Conc. Including Column Diam.	Cu Ft. Conc. Excluding Column Diam.
4′–0″	12″	9.75	8.5
4′–0″	14″	9.70	8.0
4′–0″	16″	9.60	7.6
4′–0″	18″	9.40	7.0
4′–0″	20″	9.30	6.5
4′–0″	22″	9.00	5.8
4′–0″	24″	8.80	5.3
4′–0″	26″	8.70	4.9
4′–6″	16″	13.6	11.2
4′–6″	18″	13.5	10.6
4′–6″	20″	13.3	10.0
4′–6″	22″	13.1	9.3
4′–6″	24″	12.9	8.6
4′–6″	26″	12.6	7.8
4′–6″	28″	12.3	7.1
4′–6″	30″	11.9	6.4
5′–0″	20″	18.2	14.3
5′–0″	22″	18.0	13.4
5′–0″	24″	17.8	12.6
5′–0″	26″	17.4	11.7
5′–0″	28″	17.1	10.9
5′–0″	30″	16.8	10.0
5′–0″	32″	16.4	9.1
5′–0″	34″	15.8	8.2
5′–0″	36″	15.3	7.3

	Hours	Rate	Total	Rate	Total
Column mold rental		$.....	$.....	$20.00	$20.00
Sheet metal worker.....	7	.....	.....	7.00	49.00
Cost per column.....	7		$.....		$69.00

For columns over 16′-0″ high, add $1.00 per lin. ft.

Where metal column forms are sublet to a concern specializing in this work, the costs given include organization expense or lost time of the erection crew, waiting between floors, etc., while the costs given on the previous pages are for use where the men can be used on other classes of work while concrete is being poured.

Cu. Ft. of Concrete and Sq. Ft. of Forms Required Per Lin. Ft. of Height For Round, Octagonal and Square Concrete Columns

Diam. in Inches	Round Columns			Octagonal Columns			Square Columns			Diam. in Inches
	Area Sq. In.	Cu. Ft. Conc.	Sq. Ft. Forms	Area Sq. In.	Cu. Ft. Conc.	Sq. Ft. Forms	Area Sq. In.	Cu. Ft. Conc.	Sq. Ft. Forms	
12	113	0.78	3.16	119	0.83	3.32	144	1.00	4.00	**12**
13	133	0.92	3.40	140	0.97	3.60	169	1.18	4.33	**13**
14	154	1.07	3.67	162	1.13	3.88	196	1.36	4.67	**14**
15	177	1.22	3.93	186	1.29	4.14	225	1.57	5.00	**15**
16	201	1.40	4.20	212	1.47	4.43	256	1.78	5.33	**16**
17	227	1.57	4.45	239	1.66	4.70	289	2.05	5.67	**17**
18	255	1.77	4.71	268	1.86	4.97	324	2.25	6.00	**18**
19	284	1.97	4.97	299	2.08	5.25	361	2.52	6.33	**19**
20	314	2.18	5.24	331	2.30	5.52	400	2.78	6.67	**20**
21	346	2.40	5.50	365	2.54	5.80	441	3.06	7.00	**21**
22	380	2.64	5.76	401	2.78	6.08	484	3.36	7.33	**22**
23	416	2.88	6.10	438	3.04	6.35	529	3.67	7.67	**23**
24	452	3.14	6.30	477	3.32	6.64	576	4.00	8.00	**24**
25	491	3.41	6.54	518	3.59	6.92	625	4.34	8.33	**25**
26	531	3.69	6.81	560	3.89	7.20	676	4.70	8.67	**26**
27	573	3.97	7.08	604	4.19	7.47	729	5.05	9.00	**27**
28	616	4.27	7.33	650	4.52	7.74	784	5.43	9.33	**28**
29	661	4.59	7.60	697	4.84	8.08	841	5.85	9.67	**29**
30	707	4.91	7.86	746	5.17	8.28	900	6.25	10.00	**30**
31	755	5.24	8.08	796	5.52	8.58	961	6.68	10.33	**31**
32	804	5.58	8.38	848	5.87	8.86	1024	7.10	10.67	**32**
33	855	5.94	8.67	902	6.26	9.08	1089	7.56	11.00	**33**
34	908	6.30	8.90	958	6.64	9.42	1156	8.02	11.33	**34**
35	962	6.68	9.17	1015	7.04	9.66	1225	8.50	11.67	**35**
36	1018	7.06	9.44	1074	7.42	9.92	1296	9.00	12.00	**36**

Sonotube* Fibre Forms.—Sonotubes are spirally wound, laminated fibre tubes which were developed to provide a fast and economical method of forming for round concrete columns, piers, platform supports, etc., and particularly adaptable as forms for encasing wood or steel piling. They provide a fast, economical method of forming all types of round concrete columns. They also permit new design possibilities for architects, provide new structural features for engineers, and save time, labor and money for both contractors and owners.

Sonotubes are available in standard sizes from 2" to 48" inside diameter, with wall thickness ranging from .125" to .410".

They may be obtained in any length up to 48 ft. Standard shipping lengths are 18 ft. and may be easily cut to length on the job with an ordinary hand or power saw.

There are three types of Sonotubes to meet virtually any combination of job requirements. The seamless is a premium form with specially finished inner ply which produces a smoother, continuous concrete surface. Regular A-coated is the standard form for exposed columns. For exposed columns not exceeding 12 ft. in height, the light wall A-coated is recommended.

Sonotubes are lightweight, easily handled and require few men for erection manually or with simple block and tackle. Minimum bracing is required, only fixing in place at bottom and light lumber bracing to keep them erect and plumb until tied in at top to other framing. No clamping is necessary.

Under normal conditions, for average size columns, 12" to 18" diameter, 10-ft. to 14-ft. in length, two carpenters working together with two helpers should handle, cut to length, erect and brace 18 to 22 Sonotube column forms per 8-hr. day at the following labor cost per column:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40
Helper	0.8	.....	.....	5.00	4.00
Cost per column	1.6		$.....		$9.40

Sonotube forms strip easiest and most economically from two to ten days after concrete is placed. Stripping may be accomplished with the least effort by using an electric hand saw, with blade set to cut slightly less than the wall thickness of Sonotube, and make two or three evenly spaced vertical cuts from bottom

*Sonoco Products Company, Hartsville, S. C.

to top, after which form may be pulled free from column. Sonotube forms are for one time use only.

Under normal conditions, a carpenter and a helper should strip 25 to 30 average size Sonotube column forms per 8-hr. day at the following labor cost per column:

	Hours	Rate	Total	Rate	Total
Carpenter	0.3	$.....	$.....	$6.75	$2.03
Helper	0.3	.....	.....	5.00	1.50
Cost per column	0.6		$.....		$3.53

Approximate Lineal Foot Prices of Sonotubes with A Coating

Inside Dia. and Wall Thickness	Min. Ft. For Quantity Price	Quantity Price Per Lin. Ft.	Less Than Quantity Price Per Lin. Ft.	Approx. Wt. Per Foot	Approx. Lin. Ft. Per 40-Ft. Carload
8" x .200"	1,242	$0.36	$0.50	1.7	11,898
10" x .225"	882	0.49	0.69	2.3	4,500
12" x .225"	738	0.60	0.89	2.8	3,024
14" x .250"	576	0.76	1.13	3.6	2,142
16" x .300"	414	1.01	1.53	4.8	1,620
18" x .300"	378	1.14	1.74	5.4	1,170
20" x .375"	270	1.51	2.36	7.5	954
22" x .375"	252	1.65	2.60	8.2	792
24" x .375"	234	1.82	2.95	8.9	702
26" x .375"	216	1.99	3.14	9.6	576
28" x .375"	198	2.18	3.45	10.4	414
30" x .400"	180	2.50	4.26	11.8	414
32" x .400"	162	2.66	4.48	12.6	324
34" x .400"	144	2.88	4.72	13.4	306
36" x .410"	144	3.20	5.42	14.5	306

Approximate Lineal Foot Prices of Seamless Sonotubes

8" x .200"	1,242	$0.41	$0.57	1.7	11,898
10" x .225"	882	0.56	0.78	2.3	4,500
12" x .225"	738	0.69	1.02	2.8	3,024

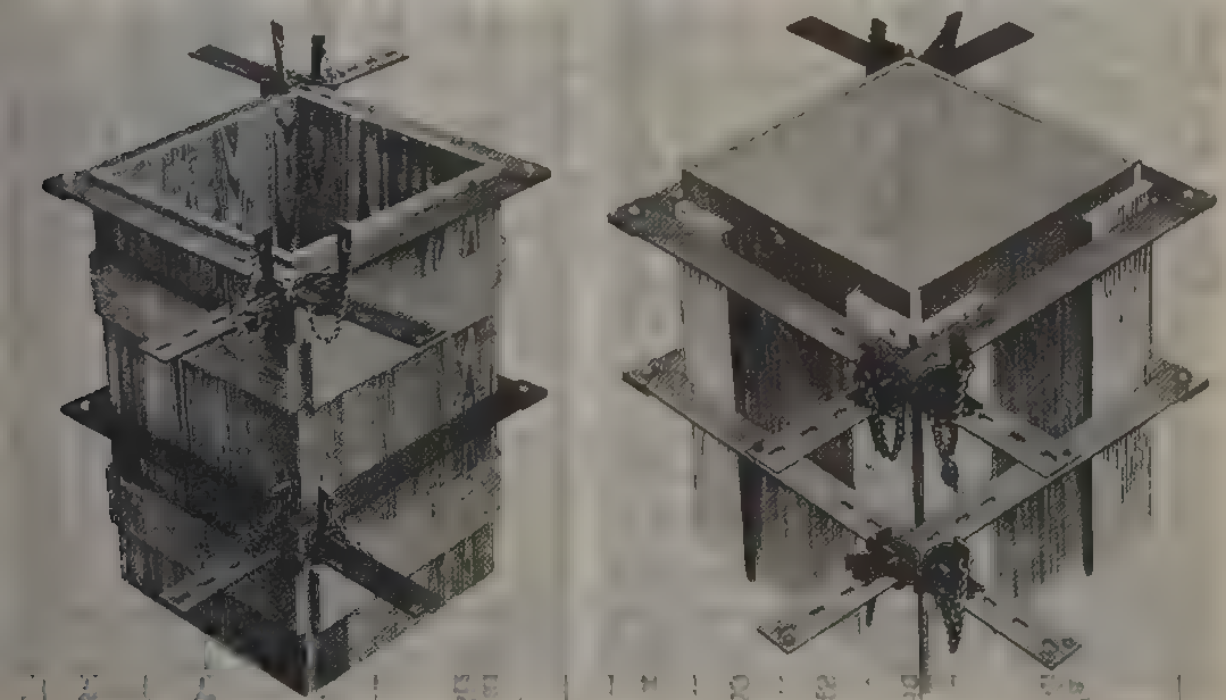
(Continued next page)

Approximate Lineal Foot Prices of Seamless Sonotubes

Inside Dia. and Wall Thickness	Min. Ft. For Quantity Price	Quantity Price Per Lin. Ft.	Less Than Quantity Price Per Lin. Ft.	Approx. Wt. Per Foot Lbs.	Approx. Lin. Ft. Per 40-Ft. Carload
14" x .250"	576	$0.89	$1.30	3.6	2,142
16" x .300"	414	1.16	1.76	4.8	1,620
18" x .300"	378	1.31	2.00	5.4	1,170
20" x .375"	270	1.73	2.71	7.5	954
22" x .375"	252	1.91	2.99	8.2	792
24" x .375"	234	2.10	3.40	8.9	702
26" x .375"	216	2.28	3.61	9.6	576
28" x .375"	198	2.51	3.96	10.4	414
30" x .400"	180	2.88	4.91	11.8	414
32" x .400"	162	3.07	4.92	12.6	324
34" x .400"	144	3.32	5.70	13.4	306
36" x .410"	144	3.68	6.24	14.5	306

Sonotubes are manufactured in twelve plants in the United States, and distributors maintain stocks in most principal cities. The above prices are f.o.b. the nearest shipping point.

Roos Adjustable Column Clamps.—Baker-Roos, Inc. of Indianapolis, Ind. manufactures metal adjustable column clamps for use on square or rectangular columns. These clamps may either be rented on a monthly basis or may be purchased. Rental costs and purchase prices are given in the table on the following page.



Roos Adjustable Column Clamps Used on Square or Rectangular Columns

Roos Column Clamps

Hinged Bar Type—2 Hinged Units—1 Complete Clamp

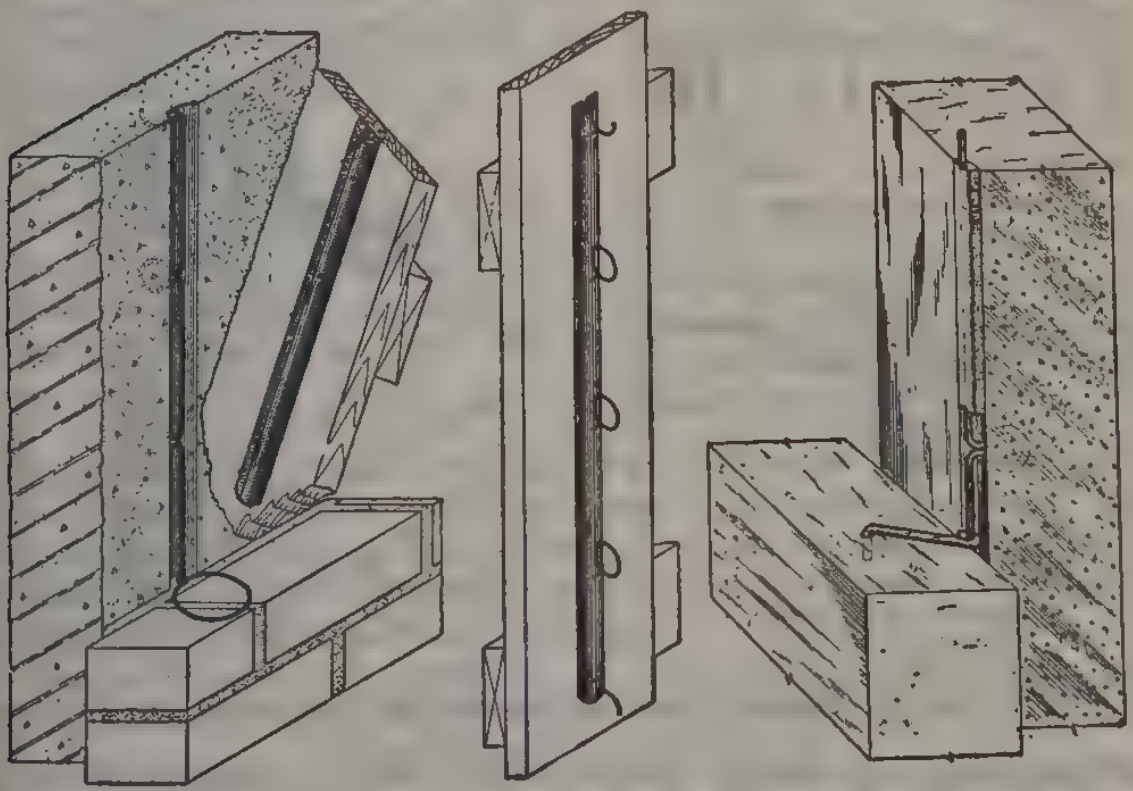
Clamp Size	Bar Size	Weight Per Clamp	Net Concrete Sizes				Purchase Price Per Pair	Rental Price Per Pair Per Mo
			With 1″ Column Lumber		With 2″ Column Lumber			
			Minimum	Maximum	Minimum	Maximum		
36″	5/16″ x 2½″ x 36″	40 lbs.	8½″ x 8½″	26″ x 26″	6½″ x 6½″	24″ x 24″	$10.10	$0.50
48″	⅜″ x 2½″ x 48″	58 lbs.	12″ x 12″	38″ x 38″	10″ x 10″	36″ x 36″	13.20	.65
60″	⅜″ x 3″ x 60″	85 lbs.	22½″ x 22½″	48½″ x 48½″	20½″ x 20½″	46½″ x 46½″	17.50	.85
36″ x 60″	1 Leg, 5/16″ x 2½″ x 36″ 1 Leg, ⅜″ x 3″ x 60″	65 lbs.	7½″ (36″ Leg) 23½″ (60″ Leg)	25″ (36″ Leg) 49½″ (60″ Leg)	5½″ (36″ Leg) 21½″ (60″ Leg)	23″ (36″ Leg) 47½″ (60″ Leg)	14.30	.70

Single Bar Type—4 Single Bars—1 Complete Clamp

Clamp Size	Bar Size	Weight Per Bar	Net Concrete Sizes				Purchase Price Per Bar	Rental Price Per Bar Per Mo.
			With 1″ Column Lumber		With 2″ Column Lumber			
			Minimum	Maximum	Minimum	Maximum		
B-5	⅜″ x 3″ x 5′–0″	24 lbs. Castings Attached	10¾″	45¼″	8¾″	43¼″	$6.50	$0.30
B-7	⅜″ x 3″ x 7′–0″ Reinforced with 3″ Channels—3′–0″ Long	44 lbs. Castings Attached	34¼″	69¼″	32¼″	67¼″	10.75	.50
B-9	⅜″ x 3″ x 9′–0″ Reinforced with 3″ Channels—5′–0″ Long	62 lbs. Castings Attached	58″	93″	56″	91″	14.00	.60

Anchoring Brick, Stone and Terra Cotta to a Concrete Backing

There are a number of methods of anchoring brick, stone and terra cotta to concrete, some of which consist of metal slots nailed to the column or beam forms, which form a slot in the concrete for placing anchors. One method known as the Tie-To* consists of a non-clog anchor insert, made from 9 ga. heavily galvanized hard steel wire, formed with 1½" anchor loops 6" on centers. It is furnished mounted and assembled on a two piece wood core. The insert is simply installed by nailing it vertically in the forms. When the forms are removed, the wood core comes with them, leaving a semi-circular impression in the surface of the concrete in the center of which is a free, clear, continuous and rigid wire support. As the masonry work progresses, Tie-To anchor rings made of 9 ga. hard steel wire, are snapped on the inserts at any course height.



Method of Applying and Using Tie-To Inserts and Anchors for Concrete, Brick and Stone.

They are furnished in 5 foot lengths but can be furnished in shorter specified lengths if desired. Anchor rings are furnished in two sizes: 3½" diam. for 4" veneer, and 1¾" for 2" veneer.

*Racine Iron and Wire Works, Inc., Racine, Wis.

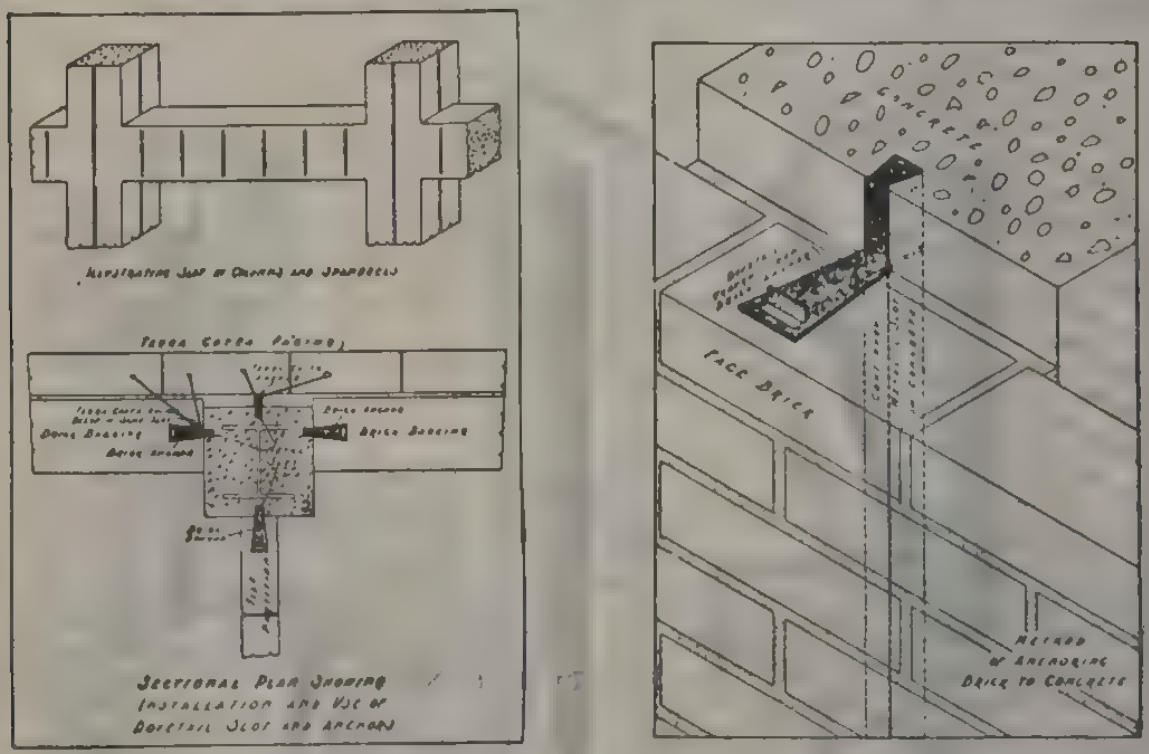
They are furnished at the following prices:

	Per 1,000 Lin. Ft.
9 Ga. Brick and Tile Anchor Insert	$85.00
8 Ga. Stone and Terra Cotta Anchor Insert	90.00
9 Ga. Anchor Rings—3½" and 1¾" in Diameter, per 1,000 pcs.	30.00
3 Ga. Stone and Terra Cotta Anchor Arms—3½"	35.00
For each additional ½", add	1.75

In the South and Southeastern states add approximately 10 percent to the above prices to take care of transportation charges.

For Colorado, Oklahoma, Texas and New Mexico, add 15 percent to the above prices.

For all states west of the Rocky Mountains, add 25 percent to the above prices.



Details Showing Dovetail Anchor Slots in Place

When installing anchor inserts, which merely consists of driving a nail through the wood core into the form, a carpenter should nail about 20 lin. ft. of cores a minute. This applies only where the cores for a number of columns are being placed at one time.

The Dovetail Anchor Slot method of anchoring masonry to concrete consists of a metal slot dovetail in cross section and anchors with dovetail ends for cut stone, brickwork and terra cotta.

The dovetail anchor slot is nailed to the form with the open side against the wood, the ends are then closed with a wood plug or they may be obtained with felt filled slots. After the concrete is poured and the forms removed, the slot remains in the concrete available at any course height to receive the anchors.

The anchors are installed by merely inserting the dovetail end of the anchor edgewise in the slot, then turning anchor crosswise of the slot with the hand, the other end of anchor being imbedded in the facing material or mortar joint. The dovetail slot holds the end of anchor securely, making any other means of fastening, drilling or boring unnecessary.

Dovetail anchor slots and anchors cost as follows:

	Price per 1,000 Lineal Feet
Open Face type anchor slot, 24 ga. galv.	$55.00
Open Face type anchor slot, 22 ga. galv.	65.00
For felt filled type anchor slot, add per 1,000 lin. ft.	15.00
Brick anchors, 16 ga. galv.	22.00
14 ga. galv.	27.50
12 ga. galv. per 1,000 pcs.	35.00
Stone anchors, ⅛"x1"x3½", $6.60; galv., per 100 pcs.	8.50
Dovetail Furring Anchors,	
16 ga 1 x 3½" long per 1000 pcs.	28.30
14 ga. galv. 3½" long, per 1,000 pcs.	35.60

All of the above prices f.o.b. Chicago.

The installation of Dovetail anchor slots consists of driving the nails through the slot into the form. A carpenter will nail two pieces, each 10′ long to a column and close the ends in approximately 1 minute. This applies where the slots for a number of columns are being placed at one time.

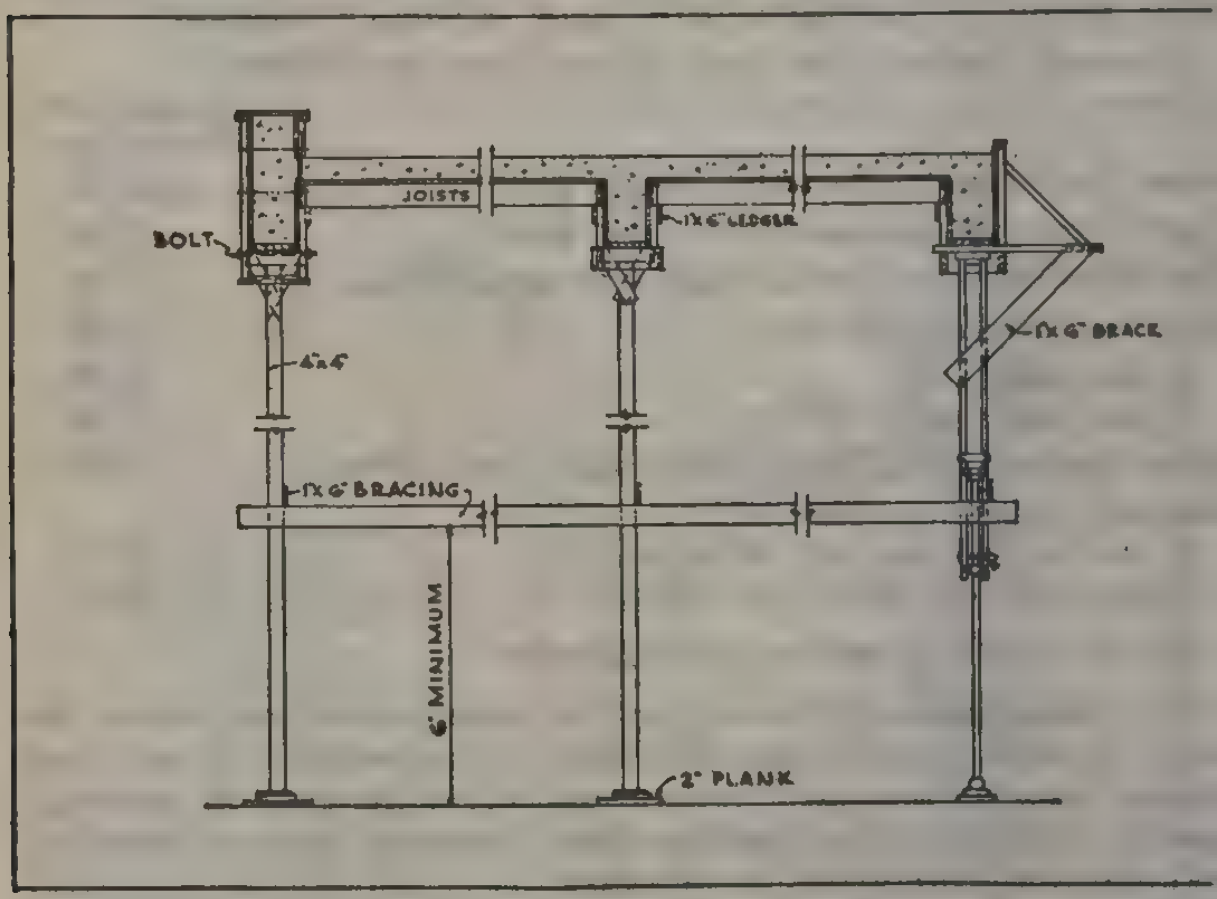
FORMS FOR CONCRETE BEAMS, GIRDERS, SPANDREL BEAMS, AND LINTELS

Forms for reinforced concrete beams, girders, lintels, etc., should be estimated by the sq. ft. obtained by adding the dimensions of the three sides of the beam and multiplying by the length. Example: a beam or girder may be marked 12"x24" on the plans but perhaps 6" of this depth is included in the slab thickness, so the form area should be obtained by taking the dimensions of the beam or girder from the underside of the slab, i.e., 18"+12"+18"=48" or 4′-0" the girth, which multiplied

by the length gives the number of sq. ft. of forms in the beam, viz., 4'-0"x18'-0"=72 sq. ft.

Spandrel beams or those projecting above or below the slab as illustrated below, should be measured in the same manner. A good rule to remember when measuring beam forms is to take the area of all forms that come in contact with the concrete.

When preparing an estimate on formwork, beams and girders should always be estimated separately, that is, the columns should be taken off, then the beams, girders and lintels, followed by the floor slabs, stairs, etc.



Method of Framing Wood Forms for Concrete Beams and Girders.

Forms for concrete beams and girders are ordinarily built up of 1" lumber, although 2" lumber is generally used for the soffits. The forms for spandrel beam sides are often built up in panels having a 2"x4" frame and intermediate braces, sheathed with 1" lumber, or where a very smooth surface is desired, plywood may be used instead of wood sheathing.

It ordinarily requires 3 to 4 ft. of lumber, b.m. to construct one sq. ft. of beam and girder forms, which includes all shoring or uprights, bracing, etc.

Sq. Ft. of Forms Required Per Lin. Ft. of Concrete Beams and Girders

Depth of Beam	Width of Beam in Inches												
	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″	18″	19″
7″	1.75	1.83	1.92	2.00	2.08	2.17	2.25	2.33	2.42	2.50	2.58	2.67	2.75
8″	1.92	2.00	2.08	2.17	2.25	2.33	2.42	2.50	2.58	2.67	2.75	2.83	2.92
9″	2.08	2.17	2.25	2.33	2.42	2.50	2.58	2.67	2.75	2.83	2.92	3.00	3.08
10″	2.25	2.33	2.42	2.50	2.58	2.67	2.75	2.83	2.92	3.00	3.08	3.17	3.25
11″	2.42	2.50	2.58	2.67	2.75	2.83	2.92	3.00	3.08	3.17	3.25	3.33	3.42
12″	2.58	2.67	2.75	2.83	2.92	3.00	3.08	3.17	3.25	3.33	3.42	3.50	3.58
13″	2.75	2.83	2.92	3.00	3.08	3.17	3.25	3.33	3.42	3.50	3.58	3.67	3.75
14″	2.92	3.00	3.08	3.17	3.25	3.33	3.42	3.50	3.58	3.67	3.75	3.83	3.92
15″	3.08	3.17	3.25	3.33	3.42	3.50	3.58	3.67	3.75	3.83	3.92	4.00	4.08
16″	3.25	3.33	3.42	3.50	3.58	3.67	3.75	3.83	3.92	4.00	4.08	4.17	4.25
17″	3.42	3.50	3.58	3.67	3.75	3.83	3.92	4.00	4.08	4.17	4.25	4.33	4.42
18″	3.58	3.67	3.75	3.83	3.92	4.00	4.08	4.17	4.25	4.33	4.42	4.50	4.58
19″	3.75	3.83	3.92	4.00	4.08	4.17	4.25	4.33	4.42	4.50	4.58	4.67	4.75
20″	3.92	4.00	4.08	4.17	4.25	4.33	4.42	4.50	4.58	4.67	4.75	4.83	4.92
21″	4.08	4.17	4.25	4.33	4.42	4.50	4.58	4.67	4.75	4.83	4.92	5.00	5.08
22″	4.25	4.33	4.42	4.50	4.58	4.67	4.75	4.83	4.92	5.00	5.08	5.17	5.25
23″	4.42	4.50	4.58	4.67	4.75	4.83	4.92	5.00	5.08	5.17	5.25	5.33	5.42
24″	4.58	4.67	4.75	4.83	4.92	5.00	5.08	5.17	5.25	5.33	5.42	5.50	5.58
25″	4.75	4.83	4.92	5.00	5.08	5.17	5.25	5.33	5.42	5.50	5.58	5.67	5.75
26″	4.92	5.00	5.08	5.17	5.25	5.33	5.42	5.50	5.58	5.67	5.75	5.83	5.92
27″	5.08	5.17	5.25	5.33	5.42	5.50	5.58	5.67	5.75	5.83	5.92	6.00	6.05
28″	5.25	5.33	5.42	5.50	5.58	5.67	5.75	5.83	5.92	6.00	6.08	6.17	6.28
29″	5.42	5.50	5.58	5.67	5.75	5.83	5.92	6.00	6.08	6.17	6.25	6.33	6.42
30″	5.58	5.67	5.75	5.83	5.92	6.00	6.08	6.17	6.25	6.33	6.42	6.50	6.58
31″	5.75	5.83	5.92	6.00	6.08	6.17	6.25	6.33	6.42	6.50	6.58	6.67	6.75
32″	5.92	6.00	6.08	6.17	6.25	6.33	6.42	6.50	6.58	6.67	6.75	6.83	6.92
33″	6.08	6.17	6.25	6.33	6.42	6.50	6.58	6.67	6.75	6.83	6.92	7.00	7.08
34″	6.25	6.33	6.42	6.50	6.58	6.67	6.75	6.83	6.92	7.00	7.08	7.17	7.25
35″	6.42	6.50	6.58	6.67	6.75	6.83	6.92	7.00	7.08	7.17	7.25	7.33	7.42
36″	6.58	6.67	6.75	6.83	6.92	7.00	7.08	7.17	7.25	7.33	7.42	7.50	7.58

An easy method of listing the dimensions for concrete and beam and girder forms at one operation, is to list the number of beams, their depth, width and length, and then at the side of the column headed "No. Pcs." place in small letters "F3S", which designates that the beam requires "forms on 3 sides." See illustrations of estimate sheet on page 326. When making the calculations on the estimate sheet, the concrete quantities should be extended in cu. ft. and the forms in sq. ft. Example: obtain the concrete quantities and form area of a beam 12″x18″-18′-0″.

Sq. Ft. of Forms Required Per Lin. Ft. of Concrete Beams and Girders

Depth of Beam	Width of Beam in Inches												
	12"	13"	14"	15"	16"	17"	18"	19"	20"	21"	22"	23"	24"
37"	7.17	7.25	7.33	7.42	7.50	7.58	7.67	7.75	7.83	7.92	8.00	8.08	8.17
38"	7.33	7.42	7.50	7.58	7.67	7.75	7.83	7.92	8.00	8.08	8.17	8.25	8.33
39"	7.50	7.58	7.67	7.75	7.83	7.92	8.00	8.08	8.17	8.25	8.33	8.42	8.50
40"	7.67	7.75	7.83	7.92	8.00	8.08	8.17	8.25	8.33	8.42	8.50	8.58	8.67
41"	7.83	7.92	8.00	8.08	8.17	8.25	8.33	8.42	8.50	8.58	8.67	8.75	8.83
42"	8.00	8.08	8.17	8.25	8.33	8.42	8.50	8.58	8.67	8.75	8.83	8.92	9.00
43"	8.17	8.25	8.33	8.42	8.50	8.58	8.67	8.75	8.83	8.92	9.00	9.08	9.17
44"	8.33	8.42	8.50	8.58	8.67	8.75	8.83	8.92	9.00	9.08	9.17	9.25	9.33
45"	8.50	8.58	8.67	8.75	8.83	8.92	9.00	9.08	9.17	9.25	9.33	9.42	9.50
46"	8.67	8.75	8.83	8.92	9.00	9.08	9.17	9.25	9.33	9.42	9.50	9.58	9.67
47"	8.83	8.92	9.00	9.08	9.17	9.25	9.33	9.42	9.50	9.58	9.67	9.75	9.83
48"	9.00	9.08	9.17	9.25	9.33	9.42	9.50	9.58	9.67	9.75	9.83	9.92	10.00
49"	9.17	9.25	9.33	9.42	9.50	9.58	9.67	9.75	9.83	9.92	10.00	10.08	10.17
50"	9.33	9.42	9.50	9.58	9.67	9.75	9.83	9.92	10.00	10.08	10.17	10.25	10.33
51"	9.50	9.58	9.67	9.75	9.83	9.92	10.00	10.08	10.17	10.25	10.33	10.42	10.50
52"	9.67	9.75	9.83	9.92	10.00	10.08	10.17	10.25	10.33	10.42	10.50	10.58	10.67
53"	9.83	9.92	10.00	10.08	10.17	10.25	10.33	10.42	10.50	10.58	10.67	10.75	10.83
54"	10.00	10.08	10.17	10.25	10.33	10.42	10.50	10.58	10.67	10.75	10.83	10.92	11.00
55"	10.17	10.25	10.33	10.42	10.50	10.58	10.67	10.75	10.83	10.92	11.00	11.08	11.17
56"	10.33	10.42	10.50	10.58	10.67	10.75	10.83	10.92	11.00	11.08	11.17	11.25	11.33
57"	10.50	10.58	10.67	10.75	10.83	10.92	11.00	11.08	11.17	11.25	11.33	11.42	11.50
58"	10.67	10.75	10.83	10.92	11.00	11.08	11.17	11.25	11.33	11.42	11.50	11.58	11.67
59"	10.83	10.92	11.00	11.08	11.17	11.25	11.33	11.42	11.50	11.58	11.67	11.75	11.83
60"	11.00	11.08	11.17	11.25	11.33	11.42	11.50	11.58	11.67	11.75	11.83	11.92	12.00
61"	11.17	11.25	11.33	11.42	11.50	11.58	11.67	11.75	11.83	11.92	12.00	12.08	12.17
62"	11.33	11.42	11.50	11.58	11.67	11.75	11.83	11.92	12.00	12.08	12.17	12.25	12.33
63"	11.50	11.58	11.67	11.75	11.83	11.92	12.00	12.08	12.17	12.25	12.33	12.42	12.50
64"	11.67	11.75	11.83	11.92	12.00	12.08	12.17	12.25	12.33	12.42	12.50	12.58	12.67
65"	11.83	11.92	12.00	12.08	12.17	12.25	12.33	12.42	12.50	12.58	12.67	12.75	12.83
66"	12.00	12.08	12.17	12.25	12.33	12.42	12.50	12.58	12.67	12.75	12.83	12.92	13.00

1'-0"x1'-6"x18'-0"=27 cu. ft. of concrete. The form area would be 18"+12"+18"=48" or 4'-0". 4'-0"x18'-0"=72 sq. ft. form area.

As an example of the lumber required for beam and girder forms, assume an inside beam 11½ wide by 1'-6" deep and 19'-0" long, supporting on each side 3 ft. of forms of a 5" solid concrete slab or its equivalent of tile and concrete joist or metal pan and concrete joist construction. See figure on page 346.

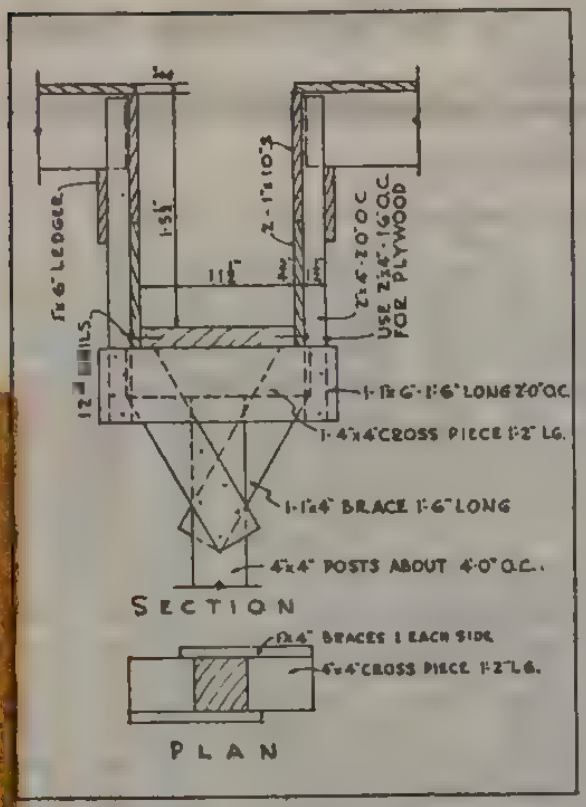
The contact area of this beam would be 2 sides 1'-6" deep and a bottom 1'-0" wide by 19'-0" long, 1'-6"+1'-6"+1'-0"=4 sq. ft.

Cu. Ft. of Concrete Required Per Lin. Ft. of Concrete Beams and Girders

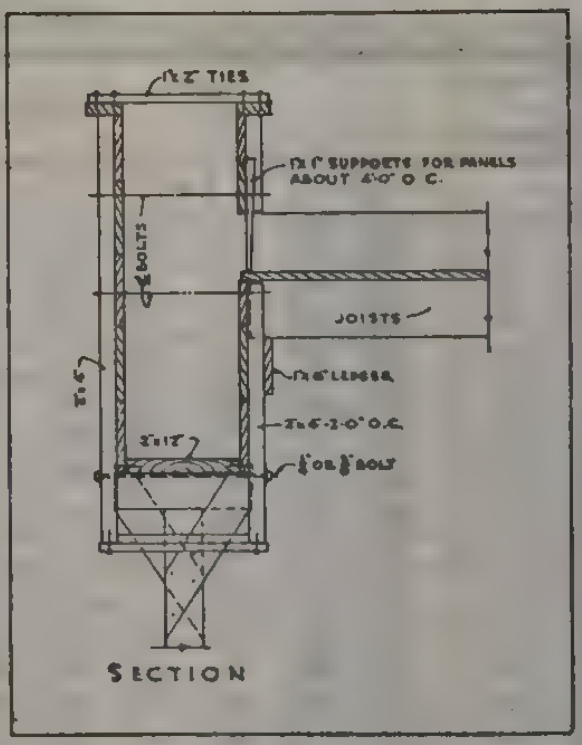
Depth of Beam	Width of Beam in Inches												
	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″	18″	19″
7″	.34	.39	.44	.49	.54	.58	.63	.68	.73	.78	.83	.88	.92
8″	.39	.44	.50	.56	.61	.67	.72	.78	.83	.89	.95	1.00	1.06
9″	.44	.50	.56	.63	.69	.75	.81	.88	.94	1.00	1.06	1.13	1.19
10″	.49	.56	.63	.70	.76	.83	.90	.97	1.04	1.11	1.18	1.25	1.32
11″	.53	.61	.69	.76	.84	.92	.99	1.07	1.15	1.22	1.30	1.38	1.45
12″	.58	.67	.75	.83	.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58
13″	.63	.72	.81	.90	.99	1.08	1.17	1.26	1.35	1.45	1.53	1.63	1.72
14″	.68	.78	.88	.97	1.07	1.17	1.26	1.36	1.46	1.56	1.65	1.75	1.85
15″	.73	.83	.94	1.04	1.15	1.25	1.35	1.46	1.56	1.67	1.77	1.88	1.98
16″	.78	.89	1.00	1.11	1.22	1.33	1.44	1.55	1.67	1.78	1.89	2.00	2.11
17″	.83	.95	1.06	1.18	1.30	1.42	1.54	1.65	1.77	1.89	2.01	2.12	2.25
18″	.88	1.00	1.12	1.25	1.38	1.50	1.62	1.75	1.88	2.00	2.12	2.25	2.38
19″	.93	1.05	1.19	1.32	1.45	1.58	1.72	1.85	1.98	2.11	2.24	2.38	2.50
20″	.97	1.11	1.25	1.39	1.53	1.67	1.81	1.95	2.08	2.22	2.36	2.50	2.64
21″	1.02	1.17	1.31	1.46	1.60	1.75	1.90	2.04	2.19	2.34	2.48	2.63	2.77
22″	1.07	1.22	1.38	1.53	1.68	1.83	1.99	2.14	2.29	2.45	2.60	2.75	2.90
23″	1.12	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.56	2.72	2.88	3.04
24″	1.17	1.33	1.50	1.67	1.83	2.00	2.17	2.33	2.50	2.66	2.83	3.00	3.17
25″	1.22	1.39	1.56	1.74	1.91	2.08	2.26	2.43	2.60	2.78	2.95	3.13	3.30
26″	1.26	1.45	1.62	1.81	1.99	2.17	2.35	2.53	2.71	2.89	3.07	3.25	3.43
27″	1.31	1.50	1.69	1.88	2.06	2.25	2.44	2.62	2.81	3.00	3.19	3.38	3.56
28″	1.36	1.56	1.75	1.94	2.14	2.34	2.53	2.72	2.92	3.11	3.31	3.50	3.69
29″	1.41	1.61	1.81	2.01	2.22	2.42	2.62	2.82	3.02	3.22	3.42	3.63	3.83
30″	1.46	1.67	1.88	2.08	2.29	2.50	2.71	2.92	3.12	3.32	3.54	3.75	3.96
31″	1.51	1.72	1.94	2.15	2.37	2.58	2.80	3.01	3.23	3.45	3.66	3.87	4.08
32″	1.56	1.78	2.00	2.22	2.44	2.67	2.89	3.11	3.34	3.56	3.78	4.00	4.23
33″	1.60	1.83	2.06	2.29	2.52	2.75	2.98	3.21	3.44	3.67	3.90	4.13	4.36
34″	1.65	1.89	2.12	2.36	2.60	2.83	3.07	3.30	3.54	3.78	4.02	4.25	4.48
35″	1.70	1.94	2.19	2.43	2.68	2.92	3.16	3.40	3.65	3.89	4.13	4.38	4.62
36″	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75

girth, multiplied by 19′-0″ long, equals 76 sq. ft. of forms requiring the following lumber:

	Feet, B.M.
Beam soffit, 1 pc. 2″x12″-20′-0″	40
Beam sides, 4 pcs. 1″x10″-20′-0″	67
Cleats, 22 pcs. 2″x4″-2′-0″	30
Cross bracing, 11pcs. 1″x6″-1′-9″	10
Shores, 5 pcs. 4″x4″-9′-0″, "T" head, bracing and sill @ 17 ft.	85
Lumber required for 76 sq. ft. forms	232



Method of Constructing Inside Beam and Girder Forms



Method of Constructing Spandrel Beam and Lintel Forms

	Feet, B.M.
Lumber required per sq. ft. contact area	3
The load on the girder form from concrete rib, 1'-0"x 1'-6"x150 lbs. per cu. ft. or	225 lbs.
Load from 5" slabs, 2 sides x 3 ft. wide plus 1'-0" beam width, 7 sq. ft. @ 100 lbs., including live load	700 lbs.
Total load per lin. ft. on each shore or post	925 lbs.
If shores are spaced 3'-0" on centers, load on each shore would be	2,775 lbs.
If shores are spaced 4'-0" on centers, load on each shore would be	3,700 lbs.
If shores are spaced 5'-0" on centers, load on each shore would be	4,625 lbs.

Using a shore 9'-0" long, spaced 4'-0" on centers, a 4"x4", S4S section will be sufficient in most instances but a 4"x4" (rough) is always better practice and does not require bracing. This loading will not apply to outside lintels or spandrel beams. See "Carrying Capacity of 4"x4" Uprights or Shores," page 356.

The following lumber will be required for each shore:

	Feet, B.M.
1 pc. 4"x4"-9'-0" (about 11'-4" story height)	12.00
1 pc. 4"x4"-1'-3" (crosspiece or "T" head)	1.67
2 pcs. 1"x4"-1'-6" braces for "T" head	1.00
1 pc. 2"x8"-2'-0" sill	2.67
Lumber required for each shore	17.34

Lintel and spandrel beams will require 3½ to 4 ft. of lumber, b.m. per sq. ft. of contact area on account of the additional shores and bracing necessary.

When beams or girders are more than 1'-6" deep, the designs given under Concrete Foundation Wall Forms should be used, which gives spacing and size of cleats or studs required, together with bracing and form ties necessary.

If adjustable shores are used (see data on adjustable shores on following pages), shores should be spaced 3'-0" apart and it will require 5 to 7 adjustable shores instead of 5 4"x4" shores.

Labor Cost of Wood Forms for Concrete Beams and Girders.

The labor cost on beam and girder forms will vary considerably on different jobs, due to the amount of duplication, size of beams and girders and the methods of framing and placing them.

On typical buildings where the same size beam and girders are used on several floors, so that the forms may be used several times with only a small amount of labor with each reuse, minimum labor costs should prevail. Also, larger beams are more economically framed than very small ones but one of the most important cost factors in the method of fabricating the units and whether they are built up in a job "shop" using power saws and electric hand saws. These are factors that cut costs and the contractor attempting to compete without using the most up-to-date methods and equipment available is bound to suffer financially.

The following labor costs are based on efficient management, economical design and labor-saving tools and equipment. If the old hand-saw methods are to be used, increase the costs given 10 to 20 per cent.

It requires 3 to 3½ ft. of lumber, b.m. to complete 1 sq. ft. of beam and girder forms, which includes uprights or "shores", beam soffits, bracing, etc.

Cu. Ft. of Concrete Required Per Lin. Ft. of Concrete Beams and Girders

Depth of Beam	Width of Beam in Inches												
	12″	13″	14″	15″	16″	17″	18″	19″	20″	21″	22″	23″	24″
37″	3.08	3.34	3.60	3.85	4.11	4.37	4.62	4.88	5.14	5.40	5.65	5.91	6.17
38″	3.17	3.43	3.70	3.96	4.22	4.49	4.75	5.02	5.28	5.54	5.81	6.07	6.34
39″	3.25	3.52	3.79	4.06	4.33	4.61	4.88	5.15	5.42	5.69	5.96	6.23	6.50
40″	3.33	3.61	3.89	4.17	4.45	4.72	5.00	5.28	5.56	5.83	6.11	6.39	6.67
41″	3.42	3.70	3.99	4.27	4.56	4.84	5.12	5.41	5.69	5.98	6.26	6.55	6.83
42″	3.50	3.79	4.09	4.38	4.67	4.96	5.25	5.54	5.83	6.12	6.42	6.71	7.00
43″	3.58	3.88	4.18	4.48	4.78	5.08	5.38	5.68	5.97	6.27	6.57	6.87	7.17
44″	3.67	3.97	4.28	4.58	4.89	5.20	5.50	5.81	6.11	6.42	6.72	7.03	7.34
45″	3.75	4.06	4.37	4.69	5.00	5.31	5.62	5.94	6.25	6.56	6.87	7.19	7.50
46″	3.83	4.15	4.47	4.79	5.11	5.43	5.75	6.07	6.39	6.71	7.03	7.35	7.67
47″	3.93	4.24	4.57	4.90	5.22	5.55	5.87	6.20	6.53	6.85	7.18	7.51	7.84
48″	4.00	4.33	4.67	5.00	5.33	5.66	6.00	6.33	6.66	7.00	7.33	7.67	8.00
49″	4.09	4.43	4.77	5.10	5.44	5.78	6.13	6.46	6.81	7.15	7.49	7.83	8.17
50″	4.17	4.52	4.86	5.21	5.56	5.90	6.25	6.60	6.94	7.29	7.64	7.99	8.34
51″	4.25	4.60	4.96	5.31	5.66	6.02	6.38	6.73	7.08	7.44	7.79	8.15	8.50
52″	4.33	4.70	5.06	5.42	5.78	6.14	6.50	6.86	7.22	7.58	7.95	8.30	8.67
53″	4.42	4.79	5.15	5.52	5.89	6.26	6.62	6.99	7.36	7.73	8.10	8.47	8.84
54″	4.50	4.88	5.25	5.62	6.00	6.38	6.75	7.13	7.50	7.88	8.25	8.63	9.00
55″	4.58	4.97	5.34	5.73	6.11	6.49	6.88	7.26	7.64	8.02	8.41	8.78	9.17
56″	4.67	5.06	5.44	5.83	6.22	6.61	7.00	7.39	7.78	8.17	8.56	8.95	9.34
57″	4.75	5.15	5.54	5.94	6.33	6.73	7.13	7.52	7.92	8.32	8.71	9.10	9.50
58″	4.84	5.24	5.64	6.04	6.44	6.85	7.26	7.66	8.06	8.46	8.86	9.26	9.67
59″	4.92	5.33	5.74	6.14	6.56	6.96	7.38	7.79	8.20	8.61	9.02	9.43	9.84
60″	5.00	5.42	5.83	6.25	6.67	7.09	7.50	7.92	8.33	8.75	9.17	9.59	10.00
61″	5.08	5.50	5.93	6.35	6.77	7.20	7.63	8.05	8.47	8.90	9.32	9.75	10.16
62″	5.17	5.60	6.03	6.46	6.89	7.32	7.75	8.18	8.61	9.04	9.47	9.91	10.34
63″	5.25	5.69	6.13	6.56	7.00	7.44	7.89	8.32	8.75	9.19	9.63	10.06	10.50
64″	5.33	5.78	6.22	6.67	7.11	7.56	8.00	8.44	8.89	9.34	9.78	10.22	10.66
65″	5.42	5.87	6.32	6.77	7.22	7.67	8.13	8.58	9.03	9.48	9.93	10.38	10.84
66″	5.50	5.96	6.42	6.87	7.33	7.79	8.25	8.71	9.17	9.63	10.08	10.55	11.00

A carpenter should frame and erect 250 to 275 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	29.0	$.....	$.....	$6.75	$195.75
Helper	14.5	.....	.....	5.00	72.50
Cost per 1,000 ft. b.m.	43.5		$.....		$268.25

If laborers are not permitted to carry the lumber and forms for the carpenters, the "helper" time given above should be figured as carpenter time.

A laborer should remove or "strip" 800 to 1,000 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Labor	9	$.....	$.....	$5.00	$45.00

Cost of 100 Sq. Ft. of Inside Beam and Girder Forms Requiring 3 Ft. of Lumber Per Sq. Ft. of Forms, Using 4"x4" Wood Shores

Material Required	Hours	Rate	Total	Rate	Total
300 ft. lumber		$.....	$.....	$0.06*	$ 18.00*
Nails, etc.		.....	.....	.01	1.00
Making Beam Soffits and Sides					
Carpenter	3.50	.....	.....	6.75	23.63
Labor helping	1.75	.....	.....	5.00	8.75
Assembling, Erecting, Shoring and Bracing					
Carpenter	5.50	.....	.....	6.75	37.13
Labor helping	2.75	.....	.....	5.00	13.75
Removing Forms					
Labor	2.75	.....	.....	5.00	13.75
Cost per 100 sq. ft.	16.25		$.....		$116.01
Cost per sq. ft.			.....		1.160
Material cost per sq. ft.			.....		.190
Labor cost per sq. ft.			.....		.970

Cost of 100 Sq. Ft. of Inside Beam and Girder Forms as Above, Using Adjustable Shores

Material Required	Hours	Rate	Total	Rate	Total
200 ft. lumber		$.....	$.....	$0.06*	$ 12.00*
Nails, etc.		.....	.....	.01	1.00
Rental 7 adjustable shores		.....	.....	.60	4.20
Making Beam Soffits and Sides					
Carpenter	3.50	.....	.....	6.75	23.63
Labor helping	1.75	.....	.....	5.00	8.75
Assembling, Erecting, Shoring and Bracing					
Carpenter	5.00	.....	.....	6.75	33.75
Labor helping	2.50	.....	.....	5.00	12.50
Removing Forms					
Labor	2.75	.....	.....	5.00	13.75
Cost per 100 sq. ft.	15.50		$.....		$109.58
Cost per sq. ft.			.....		1.096
Material cost per sq. ft.			.....		.172
Labor cost per sq. ft.			.....		.924

*Lumber cost based on using each set of forms 3 times. If same forms may be reused without working over and cutting down, omit "Labor Making Forms" after first use.

Cost of 100 Sq. Ft. of Spandrel Beam or Lintel Forms Requiring 4 Ft. of Lumber Per Sq. Ft. of Forms, Using 4"x4" Wood Shores

Material Required	Hours	Rate	Total	Rate	Total
400 ft. lumber.....		$.....	$.....	$0.06*	$ 24.00*
Nails, etc.		.....	.....	.015	1.50
Making Beam Soffits and Sides					
Carpenter	3.50	.....	.....	6.75	23.63
Labor helping	1.75	.....	.....	5.00	8.75
Assembling, Erecting, Shoring and Bracing					
Carpenter	8.00	.....	.....	6.75	54.00
Labor helping	4.00	.....	.....	5.00	20.00
Removing Forms					
Labor	3.50	.....	.....	5.00	17.50
Cost per 100 sq. ft.....	20.75		$.....		$149.38
Cost per sq. ft.....			.....		1.494
Material cost per sq. ft...			.....		.255
Labor cost per sq. ft.....			.....		1.239

Cost of 100 Sq. Ft. of Spandrel Beam or Lintel Forms as Above, Using Adjustable Shores

Material Required	Hours	Rate	Total	Rate	Total
275 ft. lumber.....		$.....	$.....	$0.06*	$ 16.50*
Nails, etc.		.....	.....	.015	1.50
Rental 9 adjustable shores		.....	.....	.60	5.40
Making Beam Soffits and Sides					
Carpenter	3.50	.....	.....	6.75	23.63
Labor helping	1.75	.....	.....	5.00	8.75
Assembling, Erecting, Shoring and Bracing					
Carpenter	7.00	.....	.....	6.75	47.25
Labor helping	3.50	.....	.....	5.00	17.50
Removing Forms					
Labor	3.50	.....	.....	5.00	17.50
Cost per 100 sq. ft.....	19.25		$.....		$138.03
Cost per sq. ft.....			.....		1.380
Material cost per sq. ft...			.....		.234
Labor cost per sq. ft.....			.....		1.146

If plywood is used for sides and soffits of beam and girder forms, it will be necessary to use 1⅝" plank for the soffit of the beam and line it with plywood on account of the weight of the concrete on the soffit, while ¾" plywood may be used for the beam sides but will require 2"x4" braces or studs on the sides 12" or 16" on centers, depending upon the depth of the beam and the pressure of the wet concrete.

*Lumber cost based on using each set of forms 3 times. If same forms may be reused without working over and cutting down, omit "Labor Making Forms" after first use.

Based on the same size beam as described on previous pages, ie., 12"x1'-6" and 19'-0" long, containing 76 sq. ft. of forms, the following lumber would be required:

Material Required		Feet, B.M.
Beam soffit, 1 pc. 2"x12"-20'-0"		40
Plywood beam soffit, 1 pc. 1'-0" x 19'-0"	19 sq. ft.	
Beam sides, 2 pcs. plywood 1'-6" x 19'-0"	57 sq. ft.	
Allowing 10 percent for waste	8	84
Cleats, 28 pcs. 2"x4"-2'-0"		38
Cross bracings, 14 pcs. 1"x6"-1'-9"		12
Shores, 5 pcs. 4"x4"-9'-0", "T" head, bracing and sill @ 17 ft.		85
Lumber required for 76 sq. ft. forms		259
Lumber required per sq. ft. contact area		3.41

The labor cost on the plywood forms would run practically the same as for other beam and girder forms because while it would not be necessary to nail the single boards together, more braces are required; the plywood must be protected with a form coating, so that the labor costs should remain practically the same.

Cost of 100 Sq. Ft. of Inside Beam and Girder Forms Requiring 3½ Ft. of Lumber Per Sq. Ft. of Forms, Using 4"x4" Wood Shores

Material Required	Hours	Rate	Total	Rate	Total
230 ft. lumber		$.....	$.....	$0.06*	$ 13.80*
110 sq. ft. plywood		.....	.....	.12	13.20
Form coating for plywood		.....	.....	.01	1.00
Nails, etc.		.....	.....	.015	1.50
Making Beam Soffits and Sides					
Carpenter	3.50	.....	.....	6.75	23.63
Labor helping	1.75	.....	.....	5.00	8.75
Assembling, Erecting, Shoring and Bracing					
Carpenter	5.50	.....	.....	6.75	37.13
Labor helping	2.75	.....	.....	5.00	13.75
Removing Forms					
Labor	2.75	.....	.....	5.00	13.75
Cost per 100 sq. ft.	16.25		$.....		$126.51
Cost per sq. ft.			.....		1.265
Material cost per sq. ft.			.....		.295
Labor cost per sq. ft.			.....		.970

*Lumber and plywood cost based on using each set of forms 3 times. If same forms may be reused without working over or cutting down, omit "Labor Making Forms" after first use.

From the above it will be seen that the plywood forms cost about 10 cts. per sq. ft. more than ordinary forms.

Forms for Upturned Concrete Beams.—When the top of a beam is higher than the floor slab level, the beam side forms for that portion above the floor must be supported on temporary legs which are removed after the concrete is poured and is still wet. It is also necessary to use spreaders to maintain the proper beam width.

While it is true that the additional form material required is negligible, the labor cost on this kind of beam side form will run 50 to 100 percent more than ordinary beam side forms.

FORMS FOR REINFORCED CONCRETE FLOORS

Forms for all types of reinforced concrete floors should be estimated by the sq. ft. taking the actual floor area or the area of the wood or metal forms that come in contact with the concrete.

The same method of measuring the plans and listing the quantities should be used whether the floor is solid concrete or one of the many combinations using clay tile, steel forms, steel decking, wire mesh or metal lath construction.

Wood Forms and Shores.—The quantity of lumber required to construct forms for the different types of floors will vary with the thickness of the concrete slab, ceiling height, etc. Floors of combination tile and concrete joist construction require less lumber per sq. ft. of forms than heavy constructed warehouse, mill, factory and industrial buildings using solid concrete floors. The number of sq. ft. of forms will be the same in both cases but the latter will require nearly twice as much lumber per sq. ft. of forms as the former.

Estimating the Cost of Form Lumber.—When computing the lumber cost per sq. ft. of forms, the estimator should study the plans carefully to determine just how many times it is possible to use the same form lumber in the construction of the building.

On 8 to 12 story buildings it may be possible to use the same lumber 3 to 4 times while on a 3 story building it might be necessary to buy sufficient lumber to form the entire building. These are items that affect the material costs and can only be determined by the estimator or contractor as they should be in position to know just how soon the forms can be wrecked and how fast they will be required to carry on the work.

On many jobs it will be more economical to use high early strength cement instead of ordinary portland cement, which will enable you to strip forms in 1 to 3 days instead of 7 to 10 days, thus saving in the number of sets of forms required.

Example: Assume the forms for an 8 story building are being estimated. It will probably be necessary to buy sufficient lumber to form 3 complete floors. If it requires 3 ft. of lumber per

sq. ft. of forms (with lumber at $150.00 per 1,000 ft.), the cost per sq. ft. of forms would be obtained by multiplying 3×.150=45 cts. If the lumber can be used 3 times during the construction of the job, 45÷3=15 cts. per sq. ft. each time the lumber is used, plus a small charge for breakage, nails, etc., making a total of 15½ to 16 cts. per sq. ft. for forms.

Form lumber that has been used 3 or 4 times will have little salvage value but each contractor should determine this for himself.

An easy method of listing at one operation, both the concrete quantities and the wood forms required is to list the slab dimensions, giving length, width and thickness. Then at the side of the column headed "No. Pcs.", place a small letter "F," which designates that forms are required.

Example: Estimate the quantities in a concrete floor slab, 16'-0" wide, 20'-0" long and 8" thick. 16×20=320 sq. ft. of forms, which is placed in the second column. 320 sq. ft. multiplied by $\frac{8}{12}$" = 214 cu. ft. of concrete in the slab. See illustration of estimate sheet on page 326.

Types of Reinforced Concrete Floors.—There are a number of distinct types of reinforced concrete floor construction which require wood forms, centering and shores, and because of the variations in costs, some of the more commonly used types will be described in detail.

Flat Slab Construction.—Mill, factory, warehouse and industrial buildings designed for heavy floor loads are usually of flat slab construction, which consists of floors without beams or girders, except spandrel beams between columns, on outside walls, and around stair wells, elevator shafts, etc. Buildings of this type usually have square or rectangular columns in all exterior walls and round interior columns. The round columns usually have a "flared" or cone head that extends into a depression in the bottom of the slab. These depressions are usually 5'-0" to 7'-0" square and 4" to 8" deep. This is necessary because of the extra reinforcing steel required to develop the required strength.

Beam and Girder Type Construction.—This is the oldest type of concrete structure, having square or round columns with beams and girders running between each row of columns and the floor slabs carried by the beams and girders and then to the columns.

Combination Clay Tile or Pan Construction with Concrete Joists.—Apartment buildings, hotels, schools, hospitals, department stores, office buildings and other structures requiring light floor loads ordinarily use this type of construction, which

consists of clay tile or metal pans in conjunction with concrete joists. This type of floor is used with either round or square columns and beams that run at right angles to the joists.

Inasmuch as this is primarily a light floor construction, the wood forms supporting the wet concrete are equally light.

Designing Forms for Reinforced Concrete Floors and Estimating Quantity of Lumber Required

The process of designing forms for reinforced concrete floors may be divided into several parts, such as determining the span of the sheathing boards; size and spacing of joists and girders or stringers, and determining the size and spacing of the upright supports or shores.

The spacing of joists for concrete floor forms is governed by the strength of the sheathing boards or of the plywood used. In ordinary building construction it is uneconomical to use heavier than 1" (S4S) lumber for sheathing, except on metal pan construction when 2"x8" (S4S) planks are ordinarily used with the planks spaced to meet the widths of the metal pans.

While a 2'-6" spacing of joists would be sufficient for strength and deflection where ¾" sheathing is used, there is danger that buggies loaded with concrete, when accidentally getting off the runways, may cause a breakage of these boards through shock. For this reason, contractors generally, have used a joist spacing of 24" or less.

When plywood panels are used for sheathing, the spacing of the joists must coincide with the sizes of the plywood panels, 4'-0"x8'-0", which means that the joists should be spaced 12", 16" or 19" on centers, depending upon the load to be carried.

Weight of Concrete Floors of Various Thicknesses

In determining the weight per sq. ft. of floor, wet concrete is figured at 150 lbs. per cu. ft. Dead load of form lumber and live load on forms while concrete is being placed is figured at 38 lbs. per sq. ft. which is sufficient for temporary construction.

Floor Thickness	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"
Conc. Wt. per Sq. ft., Lbs.	25	37.5	50	62.5	75	87.5	100	112.5	125	137.5	150
Temp. Live Load per Sq. ft., Lbs.	40	37.5	38	37.5	38	37.5	38	37.5	38	37.5	38
Total Weight per Sq. Ft., Lbs.	65	75.0	88	100.0	113	125.0	138	150.0	163	175 0	188

Table Giving Spacing of Stringers and Shores When Supporting Floor Forms for Metal Pan and Concrete Joist Construction

Using 2" plank to support the concrete joists 2'-1" or 2'-11" on centers, with stringers spaced 4'-0" apart to support the 2" plank.

TABLE FOR DESIGNING SLAB FORMS FOR REINFORCED CONCRETE FLOORS BASED ON USING ¾" SHEATHING, WITH JOISTS SPACED 2'-0" ON CENTERS

Thickness of Concrete Floor Slab and Total Dead and Live Load per Sq. Ft.

Thickness Concrete Slab	2"	3"	4"	5"	6"	7"	8"	9"	12"
Total Load per Sq. Ft., Lbs.	65	75	88	100	113	125	138	150	188

Distance Between Stringers When Joists are Spaced 2'-0" on Centers

2"x4" Joists, S4S	6'-0"	5'-6"	5'-6"	5'-0"	5'-0"	4'-6"	4'-6"	4'-0"	4'-0"
2"x6" Joists, S4S	7'-6"	7'-0"	7'-0"	6'-6"	6'-6"	6'-0"	6'-0"	6'-0"	5'-6"
2"x8" Joists, S4S	9'-6"	9'-0"	8'-6"	8'-6"	8'-0"	8'-0"	7'-6"	7'-6"	7'-0"
2"x10" Joists, S4S	11'-0"	10'-6"	10'-0"	10'-0"	9'-6"	9'-6"	9'-0"	9'-0"	8'-6"

Distance Between Shores or Supports Using Stringers of Size and Spacing as Given Below

4"x4" S4S Stringers, 5-ft. c.c.	5'-0"	4'-6"	4'-0"	4'-0"	4'-0"	3'-6"	3'-6"		. . .
4"x6" S4S Stringers, 6-ft. c.c.	6'-6"	6'-0"	6'-0"	6'-0"	6'-0"	5'-6"	5'-0"	5'-0"	4'-6"
3"x8" S4S Stringers, 6-ft. c.c.	8'-6"	7'-6"	7'-0"	7'-0"	7'-0"	6'-6"	6'-0"	6'-0"	5'-6"
2"x10" S4S Stringers, 7-ft. c.c.	7'-6"	6'-0"	5'-6"	4'-6"	4'-6"	4'-0"	. . . . .	. . . . .	. . . . .

The distance between shores or span of stringers is generally an even fraction of their length. Stringers 14'-0" long will permit a spacing of 4'-8" or 7'-0", while 18'-0" stringers will permit spans of 3'-7", 4'-6", 6'-0" and 9'-0".

Based on using yellow pine, Douglas fir or woods of equal strength.

The table gives the sizes of stringers and the distance between supports or shores when supporting various floor loads.

Size of Stringer	Thickness of Floor in Inches ..... Weight of Floor per Sq. Ft.*	6+2½ 86 lbs.	8+2½ 92 lbs.	10+2½ 98 lbs.	12+2½ 105 lbs.	14+2½ 112 lbs.
		Distance Between Shores or Supports				
4"x 4" S4S	.....	5'-0"	4'-9"	4'-8"	4'-8"	4'-6"
3"x 6" S4S	.....	6'-6"	6'-5"	6'-3"	6'-1"	6'-0"
4"x 6" S4S	.....	7'-0"	7'-0"	6'-8"	6'-7"	6'-6"
3"x 8" S4S	.....	8'-0"	8'-0"	7'-6"	7'-6"	7'-6"
2"x10" S4S	.....	8'-0"	8'-0"	7'-6"	7'-6"	7'-6"

*Includes dead weight of concrete and 38 lbs. per sq. ft. for live load during construction. Joists 5" wide, 20" wide pans.

The above tables are based on using yellow pine, Douglas fir or woods of equal strength.

Data on Plywood Sheathing

When plywood is used for sheathing instead of ¾" boards, the following loads may be safely carried, based on a deflection of 1/270 of the span, which is commonly used in concrete work.

If load is continuous over two or more spans, the deflection will be approximately ½ that shown, or in other words, twice the load may be carried:

	12" Span	16" Span	20" Span
Using ⅝" plywood	510 lbs.	221 lbs.	110 lbs.
Deflection in Inches	.05-in.	.065-in.	.07-in.
Using ¾" plywood	800 lbs.	330 lbs.	170 lbs.
Deflection in Inches	.05-in.	.06-in.	.065-in.

The above deflections for Douglas Fir plywood apply when the grain of the face plies is parallel to the span, i.e., when panels are placed lengthwise across the supports. When panels are placed parallel to the supports, the loads on ⅝" plywood are only 50 percent of those given above and for ¾" plywood, use 75 percent of the above loads.

When plywood panels are used for sheathing the spacing of the joists must coincide with the sizes of the plywood panels, 4'-0"x8'-0", which means the joists should be spaced 12", 16" or 19" on centers, depending upon the load to be carried. Joists must be doubled at joints in plywood unless 4" wide joists are used.

Carrying Capacity of 4"x4" Uprights or Shores.—The carrying capacity of a given size upright or shore is generally limited by two principal factors. The first is compression at

right angles to the fibers which the shore exerts on the cross beam or stringer. The stress per sq. in. on the bearing area of the stringer on the shore should not greatly exceed 500 lbs. per sq. in. for Yellow Pine, Western Fir or similar lumber, otherwise there is a noticeable impression of the shore into the fibers of the stringer, especially when the lumber is green or water soaked after a long rain. This often amounts to ⅛". Hence a (4"x4", S4S), 3½"x3½" upright should never be loaded to more than 6,000 lbs., no matter now short it is, and a 4"x4" rough shore should not be loaded to more than 8,000 lbs.

The other principal limitation of strength is due to the length of the shore and the degree of crookedness in its length. Every experienced contractor knows that shores often show bows of 1" to 2" and if it is further considered that the shores are not cut off exactly square to their length, the carrying capacity of most shores are greatly limited by the eccentric loading impressed on them by the uneven bearing of the stringer and the bow in the shores.

The following table gives the permissible load on shores for various lengths and eccentricities:

Safe Load in Pounds on Uprights or Shores of Various Lengths

Length of Upright or Shore	4"x4" S4S Yellow Pine or Fir		4"x4" Rough Yellow Pine or Fir		4"x4" Rough Wisconsin Hemlock	
	8'-0"	10'-0"	8'-0"	10'-0"	8'-0"	10'-0"
Eccentricity						
(Bow+Top) 0" ..	6,000	6,000	8,000	8,000	8,000	8,000
(Bow+Top) 1" ..	5,700	4,800	8,000	7,100	7,300	5,600
(Bow+Top) 1½"	4,700	3,900	7,300	5,800	6,000	5,100
(Bow+Top) 2" ..	4,200	3,400	6,700	5,500	5,200	4,400
(Bow+Top) 2½"	3,600	3,000	5,300	4.500	4,800	4,100
(Bow+Top) 3" ..	3,400	2,800	5,100	4,300	4,500	3,800

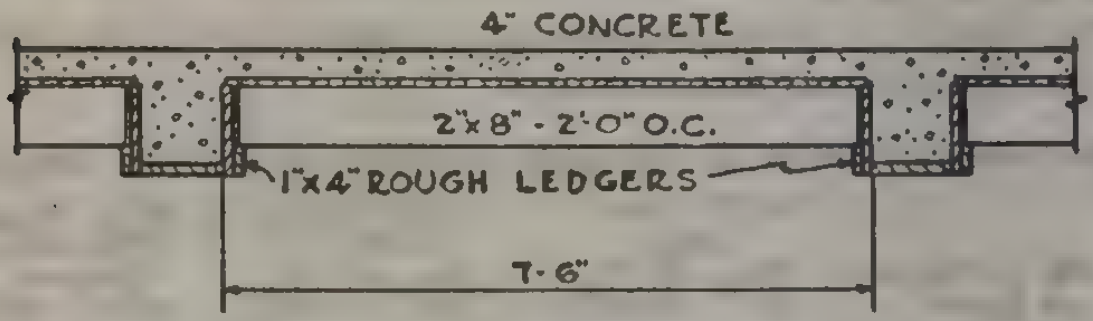
Lintels as a rule produce quite large eccentricites on the shores due to the load from the adjoining slab, which comes through on the inside of the lintel forms onto the shore, therefore contractors should never allow a load larger than those given for 3" eccentricity for shores supporting lintels. One frequently sees lintels supported by shores spaced less than 2'-0" on centers, which is a clear waste of money.

Where the height of the uprights or shores are longer than given in the above table, it is advisable to cross brace the shores, in which case the vertical distance between braces plus 40 percent, may be taken as the post height. Example: Using a 16'-0"

shore, with 2 rows of cross bracing at 6'-0" and 12'-0" above the floor. Distance between braces 6'-0" plus 40 percent, or 2.40 ft. making the capacity the same as a shore 8.40 or practically 8'-6" long. Thus an 8'-0" shore good for 8,000 lbs. would still be good for 8,000 lbs. when 16'-0" long, if cross braced by two rows of bracing 6'-0" and 12'-0" above the floor.

When computing the quantity of lumber required for wood posts or shores, the following materials are usually required for one complete shore, based on a shore 10'-0" long or sufficient for a 12'-0" story height:

	Feet, B.M.
Shore, 1 pc. 4"x4"-10'-0"	13.33
Sill, 1 pc. 2"x8"-2'-0"	2.67
Wedges, 1 pc. 2"x4"-1'-0"	.67
Scab, 1 pc. 1"x4"-1'-6"	.50
Feet of lumber, b.m. required for each 10'-0" shore	17.17
For each 2'-0" in length of shore, add or deduct	2.67



Method of Constructing Forms for Beam and Girder Type Solid Concrete Floor Slabs

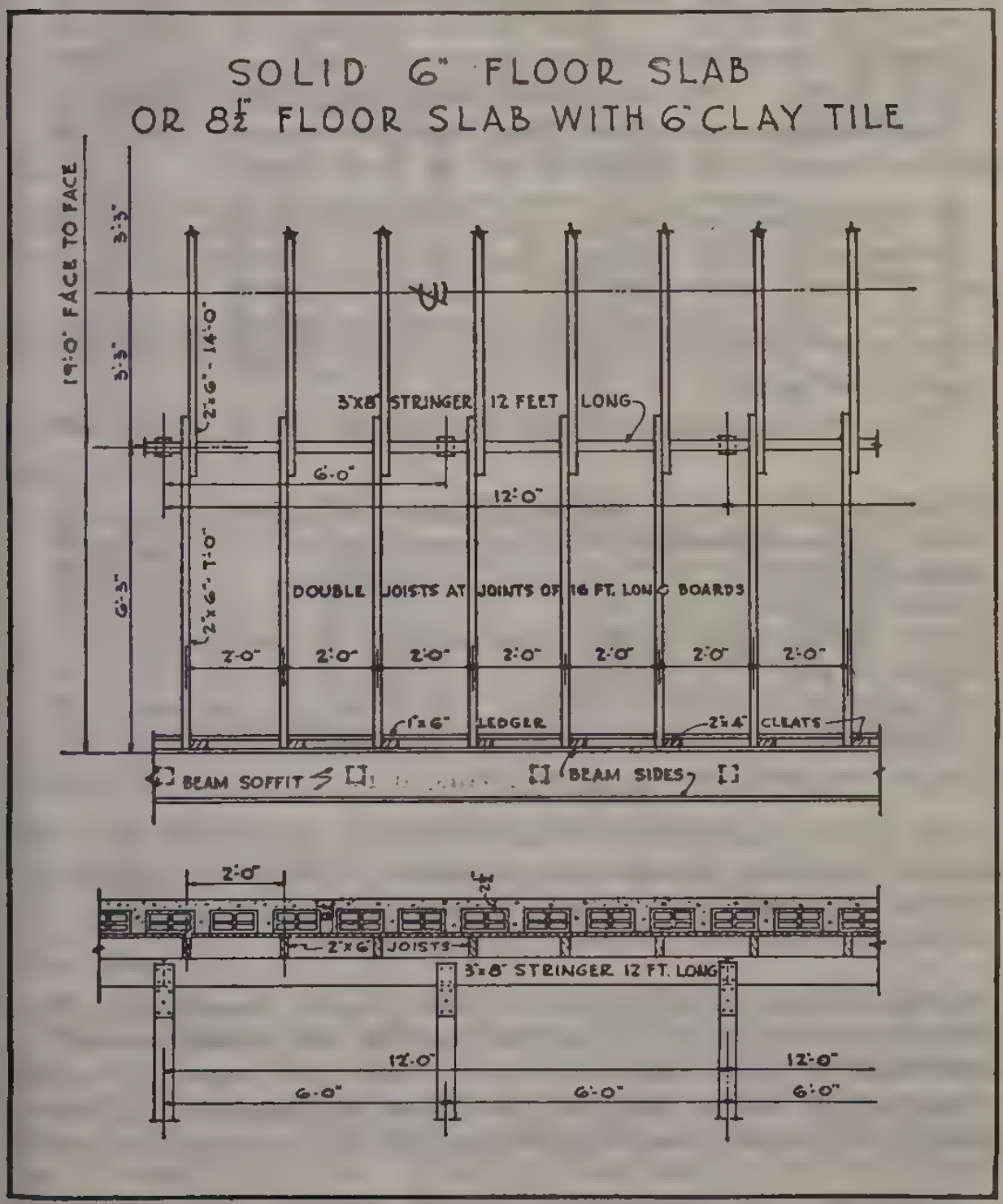
Estimating the Quantity of Lumber Required for Forms for Beam and Girder Type Solid Concrete Floor Slabs.—The accompanying illustrations give detailed designs for forms from which the lumber required per sq. ft. of forms may be computed.

The accompanying illustration shows a 4" concrete floor slab having a 7'-6" clear span between beams. Using a joist spacing of 2'-0" as given in the table for joist spacing on page 364, 2"x8" joists will carry the required load.

For a floor area 2'-0"x7'-6" containing 15 sq. ft. the following lumber will be required:

	Feet, B.M.
Sheathing, 2'-0"x7'-6"=15 sq. ft. plus 20% waste	18
Joist, 1 pc. 2"x8"-8'-0", plus 10% for joints	12
Ledger boards, 2 pcs. 1"x4"-2'-0"	1
Total lumber required for 15 sq. ft. forms	31
Feet of lumber, b.m. required per sq. ft. of forms	2.1

For a 6" solid concrete slab or for an 8½" slab with 6" clay tile fillers, having a clear span of 11'-0" between girders, ordinarily it is not economical to support joists having a 11'-0" span directly on the girders and it is better practice to provide a stringer or girt half-way between the concrete beams so that the joists have a span of only 5'-6". Using a joist spacing of 2'-0",



Method of Constructing Forms for Beam and Girder Type Solid Concrete Floors or Combination Clay Tile and Concrete Joist Floors. See Page 363.

a 2"x6" joist is sufficiently strong, as shown by the table of joist spacings. The same table shows that a 4"x6" supported by shores 6'-0" on centers will suffice.

A floor area 2'-0"x11'-0" containing 22 sq. ft. will require the following lumber:

	Feet, B.M.
Sheathing, 2'-0"x11'-0"=22 sq. ft. plus 20% waste	27
Joists, 1 pc. 2"x6"-12'-0", plus 10% for joints	13
Stringer, 1 pc. 4"x6"-2'-0"	4
Shore, ⅓ of a 4"x4"-10'-0", S4S, plus sill, wedges, 18÷3=	6
Total lumber required for 22 sq. ft. forms	50
Feet of lumber, b.m. required per sq. ft.of forms	2.25

If shores require bracing, add 0.1 ft. b.m. per sq. ft. of slab.

Assuming a solid concrete floor slab 16'-0" wide, 19'-0" long and 12" thick, containing 304 sq. ft. of slab forms.

Joists will be 2"x6" spaced 24" apart, supported by 3 lines of 3"x8"-16'-0" stringers, which in turn are supported by 4"x4" shores 5'-4" apart.

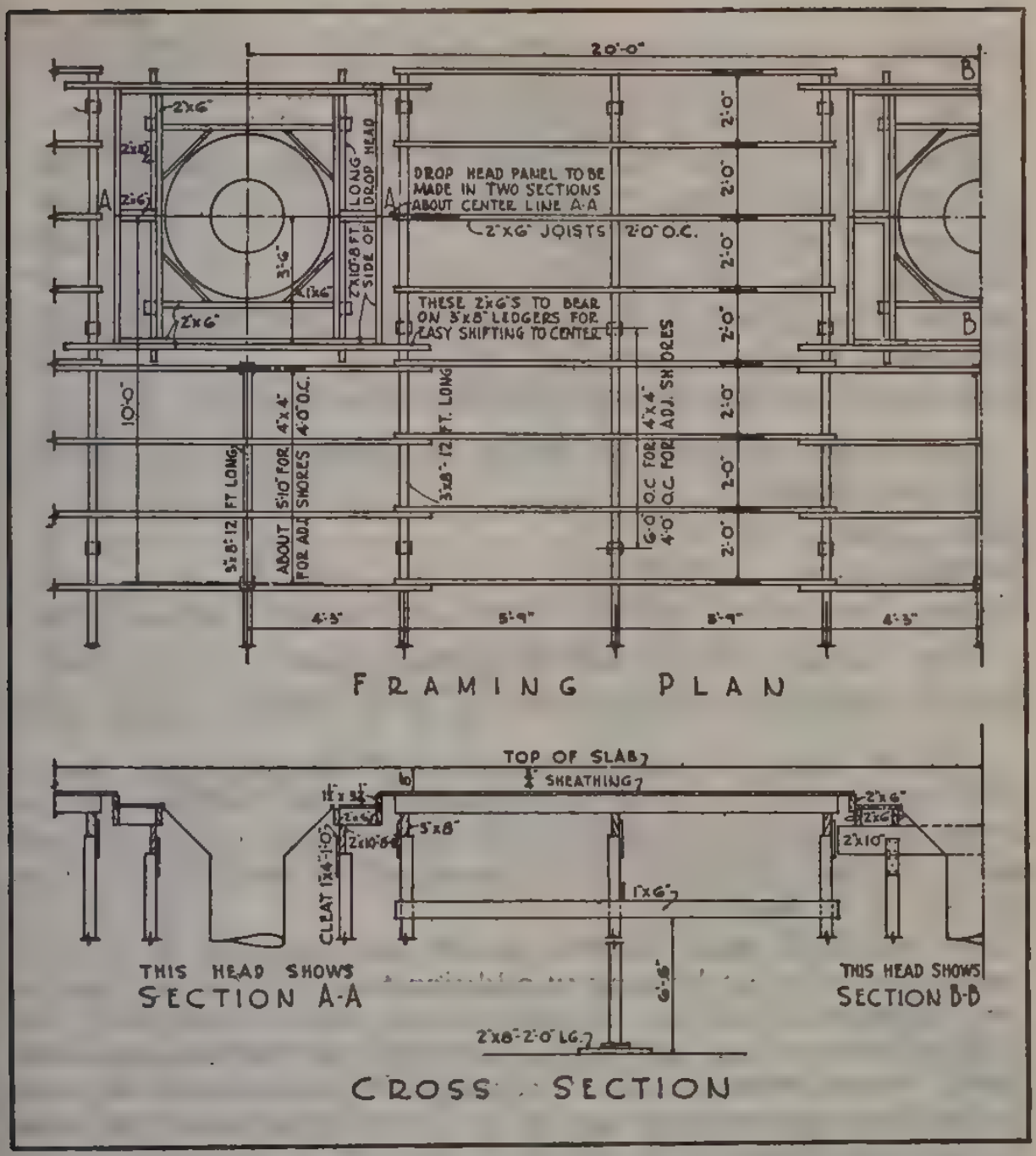
The following lumber will be required for 304 sq. ft. of forms:

	Feet, B.M.
Sheathing, 16'-0"x19'-0" 304 sq. ft. plus 20% waste	365
Joists, 9 pcs. 2"x6"-14'-0"	126
Joists, 9 pcs. 2"x6"-7'-0"	63
Stringers, 3 pcs. 3"x8"-16'-0"	96
Shores, 9 pcs. 4"x4"-10'-0", including sills and wedges	153
Braces, 6 pcs. 1"x6"-16'-0"	48
Joist support at girders, 2 pcs. 1"x6"-16'-0"	16
Total lumber required for 304 sq. ft. forms	867
Lumber required per sq. ft. of forms, b.m.	2.85

The above quantities are based on the assumption that the ends of joists and stringers are supported by the beam and girder forms. If a wall bearing job without beams and girders, the following additional lumber will be required:

	Feet, B.M.
Stringers, 2 pcs. 2"x8"-16'-0" at wall	43
Shores, 6 pcs. 4"x4"-10'-0", including sills and wedges	102
Braces, 2 pcs. 1"x6"-16'-0"	16
Additional lumber required for 304 sq. ft. forms	161
Additional lumber, b.m. required per sq. ft.	0.53

Estimating the Quantity of Lumber Required for Flat Slab Concrete Floor Forms.—Assume a flat slab having a 20'-0" span,



Method of Constructing Forms for Flat Slab Concrete Floors

with 7'-0" square drop heads, 8" thick as shown in illustration.

The maximum span of the joists is 5'-9" and the table of Joist Spacing shows that 2"x6" joists are sufficiently strong; also that 3"x8" stringers are sufficient. The load on the shores of the center stringer will be 5'-9"×6'-0"=34.5 sq. ft. at 138 lbs. per sq. ft. equals 4,761 lbs. Good practice requires a 4"x4" shore rough, although a 4"x4", S4S, with bracing will do.

The lumber required for a 20'-0"x20'-0" panel is as follows:

	Feet, B.M.
Sheathing, 400 sq. ft. plus 20% waste	480
Using 16'-0" long floor sheathing boards will require 9 joists (a double joist being placed at the joint) or for 20 ft. it will require 11¼ pcs 2"x6"-12'-0" joists (1¼x9)	135
Column Strips, 9 joists 2"x6"-10'-0"	90
Stringers, 3 pcs. 3"x8"-20'-0"	120
Stringers, 1 pc. 3"x8"-12'-0"	24
Shores, 13 pcs. 4"x4"-10'-0" plus sills, wedges, etc. @ 17 ft.	221
Horizontal bracing, 7 pcs. 1"x6"-20'-0"	70
X Bracing, not less than ⅓ horizontal bracing	23
Total lumber required for 400 sq. ft. forms	1,163
For Drop Heads	
Joists, 5 pcs. 2"x6"-14'-0"	70
Stringers, 2 pcs. 2"x8"-8'-0"	21
Shores, 4 pcs. 4"x4" at 17 ft. b.m.	68
Total lumber required including drop heads	1,322
Feet of lumber, b.m. required per sq. ft of forms	3.31

A 10'-0" shore is sufficient for a 12'-0" story height. For a 14'-0" story height it will be necessary to add 2'-0" to each of 17 shores or 34×1.33 ft.=45 ft. b.m. which adds 0.11 ft. b.m. per sq. ft. of floor. A 16'-0" story height will require 0.23 ft. b.m. per sq. ft. of floor.

For an 18'-0" story height, it will be necessary to add for another set of cross bracing in addition to the 0.33 ft. of lumber, b.m. required for shores. Another set of cross bracing will add 93 ft. of lumber b.m. for 400 sq. ft. of floor or 0.23 ft. b.m. additional, which with the 0.33 ft. required for shores, will increase the lumber required per sq. ft. to 3.31+.33+.23=3.87 ft. b.m. per sq. ft. of forms.

A 20'-0" story height will add another 0.11 ft. for extra length of shores, or a total of 3.98 ft. b.m. per sq. ft. of forms.

Where plywood is used for floor sheathing, there is at least a 10 percent waste in flooring, and while its use saves 480 ft. b.m. for sheathing, it is necessary to use more joists, because the joists should not be spaced over 19" on center, and the joists must be doubled every 8'-0" instead of 16'-0" where 16'-0" long sheathing boards are used.

In 400 sq. ft. of forms, the following additional lumber would be required:

	Feet, B.M.
Extra joists, 4 pcs. 2″x6″-12′-0″	48
Extra joists, 2 pcs. 2″x6″-10′-0″	20
Total extra lumber required for 400 sq. ft. forms	68
Extra lumber required per sq. ft. of forms	0.17

If adjustable shores are used instead of 4″x4″ shores, stringers must be supported every 4′-0″ in order to reduce the load to not much more than 3,000 lbs. per shore although some adjustable shores will carry up to 6,000 lbs. This will require 17 to 23 adjustable shores instead of 17 pcs. of 4″x4″ shores (247 ft. b.m.) and 9 pcs. of horizontal bracing, 1″x6″-20′-0″ (90 ft. b.m.) instead of 7 pcs. of 1″x6″-20′-0″ (70 ft. b.m.) and the X bracing will also be increased by 7 ft. b.m.

Using adjustable shores, 4″x4″ stringers can be used instead of 3″x8″ stringers, which will result in the following saving:

		Feet, B.M.
Shores, 17 pcs. 4″x4″-10′-0″		247
Stringers, 4″x4″ instead of 3″x8″, saving		44
Total saving using adjustable shores		291
Extra 1″x6″ required for bracing	27	
Extra sills, 6 pcs. 2″x10″-2′-0″	20	47
Total saving on 400 sq. ft. forms		244
Total saving per sq. ft. of forms b.m.		0.61

On the other hand it will be necessary to handle 17 to 23 shores weighing 1,000 to 1,400 lbs. while the 224 ft. saving weighs only 725 lbs.

For a 12″ thick flat slab having a 20′-0″ span, the lumber required can be approximated as follows:

	Feet, B.M.
Sheathing, per sq. ft. forms	1.20
Joists, same spacing but using 2″x8″ joists	0.75
Stringers, same as before	0.33
Shores, spacing will be 4′-6″, requiring 21 shores	0.90
Bracing, 9 pcs. 1″x6″-20′-0″	0.23
X bracing, ⅓ of horizontal bracing	0.08
Drop heads, same as before	0.25
Total lumber, b.m. per sq. ft. for 12′-6″ story height	3.74
For each 2 ft. in story height, more or less, add or deduct per sq. ft.	.14

Lumber Required for Floor Forms Using Clay Tile and Concrete Joist Construction.—Assuming a floor slab 16′-0″ wide and 19′-0″ long, 8½″ thick, as illustrated on page 359, containing 304 sq. ft. of forms, the following lumber will be required:

	Feet, B.M.
Sheathing, 16'-0"×19'-0"=304 sq. ft. plus 20% waste	365
Joists, 9 pcs. 2"x6"-14'-0"	126
Joists, 9 pcs. 2"x6"-7'-0"	63
Stringers, 2 pcs. 3"x8"-16'-0"	64
Shores, 4½ pcs. 4"x4"-10'-0", including sills and wedges	77
Joist support at girders, 2 pcs. 1"x6"-16'-0"	16
Braces, 4 pcs. 1"x6"-16'-0"	32
Total lumber required for 304 sq. ft. forms	743
Lumber required per sq. ft. of forms, b.m.	2.45

The above quantities are based on the assumption that the ends of the joists and stringers are supported by the beam or girder forms. If a wall bearing job, without beams or girders, requiring additional stringers and shores at walls, add the following:

	Feet, B.M.
Stringers, 2 pcs. 2"x8"-16'-0"	42
Shores, 2¼ pcs. 4"x4"-10'-0", including sills and wedges	39
Braces, 2 pcs. 1"x6"-16'-0"	16
Total additional lumber required for 304 sq. ft. forms	97
Additional lumber required per sq. ft. of forms	0.32

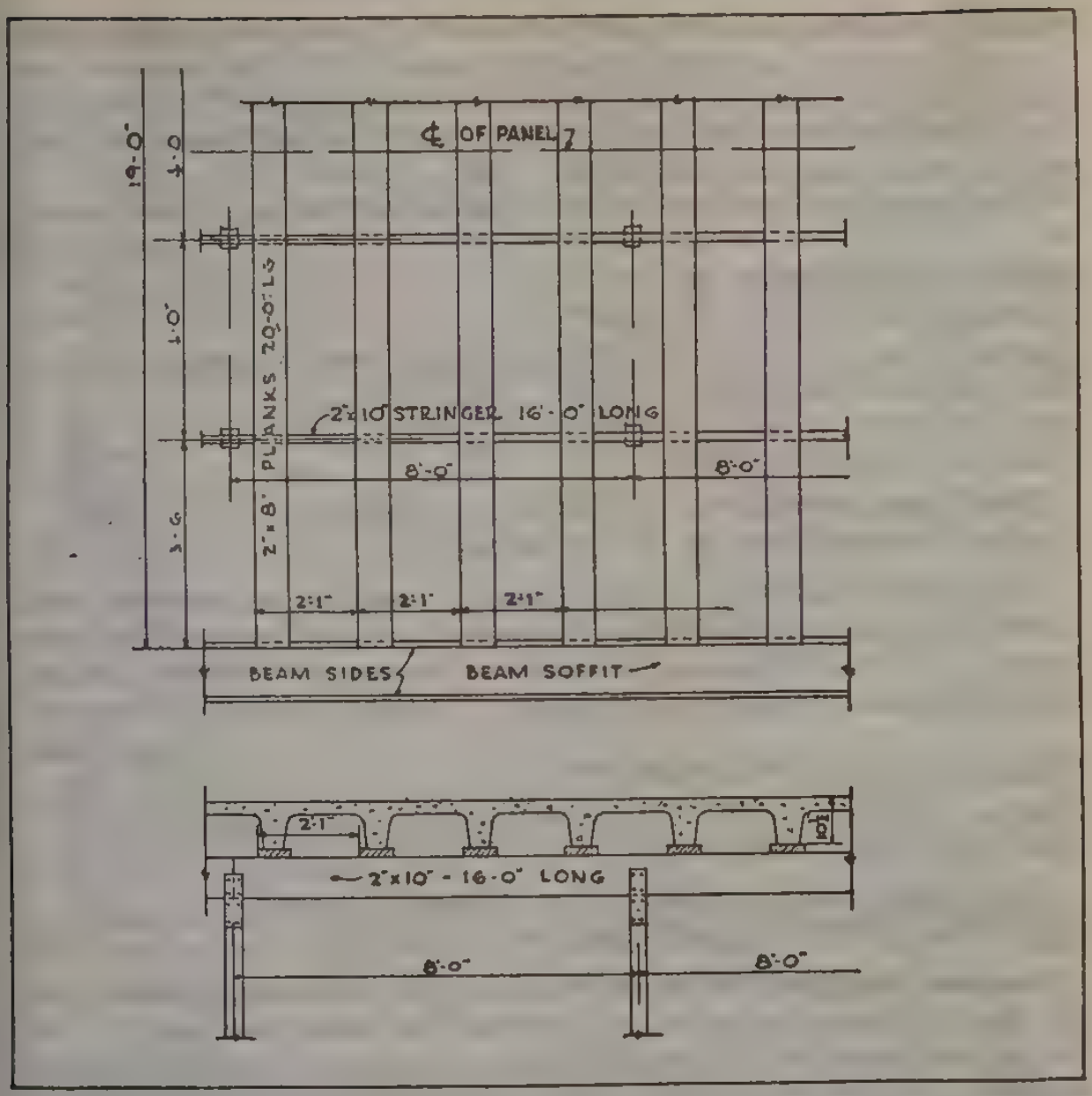
Weight of Combination Metal Pan and Concrete Joist Floors

Based on concrete joists 4", 5" and 6" wide, with a 2½" concrete slab on top, using metal pans of various depths and widths.

Concrete Thickness, Inches	2½"	2½"	2½"
Width of Concrete Joists, Inches	4"	5"	6"
Using	Weight per Sq. Ft. of Slab, Pounds		
Metal Pans 6" deep, 20" wide	45	48	50
Metal Pans 6" deep, 30" wide	41	43	45
Metal Pans 8" deep, 20" wide	51	54	57
Metal Pans 8" deep, 30" wide	45	48	50
Metal Pans 10" deep, 20" wide	56	60	64
Metal Pans 10" deep, 30" wide	50	52	55
Metal Pans 12" deep, 20" wide	63	67	72
Metal Pans 12" deep, 30" wide	54	57	61
Metal Pans 14" deep, 20" wide	..	75	80
Metal Pans 14" deep, 30" wide	..	62	66

For each ½" variation in slab thickness, add or subtract 6.25 lbs. per sq. ft. of floor.

Add 38 lbs. per sq. ft. to the above weights to take care of temporary dead and live load on floors while concrete is being poured.



Method of Constructing Forms for Floors of Combination Metal Pans and Concrete Joist Construction

Lumber Required for Floor Forms Using Metal Pans and Concrete Joist Construction.—Assume a slab of 19′-0″ clear span and 16′-0″ long, using 8″ metal pans with 5″ wide ribs spaced 2′-1″ on centers and a 2½″ concrete top over the entire slab.

According to the above table this construction weighs 52 lbs. per. sq. ft. and including a 38 lb. live load during construction, makes a total load of 90 lbs. per sq. ft.

It is customary to use 2″x8″, S4S, planks to support the concrete ribs or joists. If the planks are continuous without patching at the end spans, a span of 4′-0″ will support a load of 265 lbs. per lin. ft. with a deflection of .235 in. In this instance the load is 2.09×90 lbs. per sq. ft.=188 lbs. per lin. ft. which

reduces the deflection to 0.166" or about $\frac{1}{6}$", which is permissible.

It will require a stringer or girt every 4'-0" to support the planks and the load per lin. ft. on the stringers will be 360 lbs.

A 2"x10"-16'-0", S4S, will easily carry this uniform load per lin. ft. when supported by 4"x4" shores spaced 8'-0" apart.

The following lumber will be required for 304 sq. ft. of forms:

	Feet, B.M.
Planks, 9 pcs. 2"x8"-20'-0"	240
Stringers, 4 pcs. 2"x10"-16'-0"	107
Shores, 8 pcs. 4"x4"-10'-0", including sills and wedges	136
Joist supports at girders, 2 pcs. 1"x6"-16'-0"	16
Bracing, 4 pcs. 1"x6"-16'-0"	32
Bracing, 2 pcs. 1"x6"-20'-0"	20
Total lumber required for 304 sq. ft. forms	551
Lumber required per sq. ft. of forms, b.m.	1.8

The above quantities are based on the assumption that the ends of the joists and stringers are supported by the beam and girder forms. If a wall bearing job without beams or girders, requiring additional stringers and shores at walls, add the following:

	Feet, B.M.
Stringers, 2 pcs. 2"x10"-16'-0"	54
Shores, 4 pcs. 4"x4"-10'-0", including sills and wedges	68
Bracing, 2 pcs. 1"x6"-16'-0"	16
Additional lumber required for 304 sq. ft. forms	138
Additional lumber required per sq. ft. of forms	0.45

Lumber Required for Slab Forms.—The following tables give the approximate quantity of lumber required per sq. ft. of forms for floors of different thickness and with varying ceiling heights. These tables are only approximate as every building is different and the quantities will vary with the span, ceiling height, slab thickness and weight of the wet concrete to be supported.

Also, the following tables are based on using 4"x4" shores or uprights. If adjustable shores are used it will be necessary to deduct the lumber required for 4"x4"'s and add cost or rental of adjustable shores. Add cost of additional bracing as more shores and bracing are frequently required.

The difference in the quantity of lumber required per sq. ft. for floors having 10'-0" ceiling heights and those having 20'-0" ceiling heights is principally in the shoring and bracing. If adjustable shores are used, deductions can be made on the following basis: Floors 3" to 6" thick having 10'-0" ceiling heights, require $\frac{1}{3}$ to $\frac{3}{8}$ ft. of lumber per sq. ft. for shores; 7"

to 9" slabs require ½ to ⅝ ft.; and 10" to 12" slabs require ⅝ to ¾ ft. of shoring lumber per sq. ft. of floor.

The above quantities can be used for all 10'-0" story heights, plus the additional lumber given in the tables for higher ceiling heights.

The forms are designed in yellow pine, Douglas fir, or woods of equal strength, with the loads computed as follows: wet concrete 150 lbs. per cu. ft. Dead load of form lumber and live load on forms while concrete is being placed at 38 lbs. per sq ft.

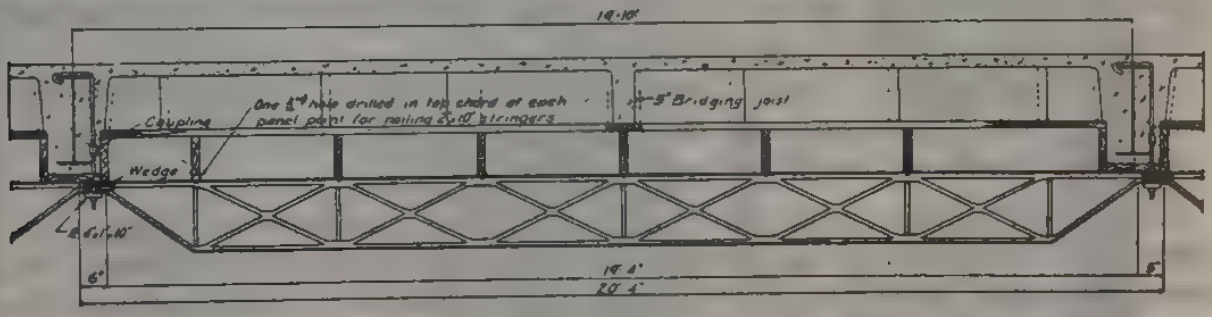
Number of Feet of Lumber Required for One Sq. Ft. of Flat Slab Concrete Floor Forms

Ceiling Height in Feet	Thickness of Slab in Inches			
	6"	8"	10"	12"
	113 lbs.	138 lbs.	163 lbs.	188 lbs.
10	3.0	3.1	3.4	3.6
12	3.1	3.2	3.5	3.7
14	3.3	3.4	3.6	3.9
16	3.4	3.5	3.9	4.0
18	3.4	3.8	4.2	4.4
20	3.5	3.9	4.3	4.6

The above quantities include lumber required for forming drop heads.

If adjustable shores are used, deduct lumber quantities given in descriptive matter on previous pages.

Using Steel Truss Joists Instead of Shoring for Supporting Formwork for Reinforced Concrete Floors.—In steel frame buildings where clear floor space is essential, steel truss joists



Steel Joists Used for Supporting Concrete Floor Forms

may be used for supporting the wood formwork, as shown in the accompanying illustration.

This is a simple method that is very effective as the salvage value of the truss joists is very high.

Sectional Steel Shoring.—Many contractors now use their sectional steel scaffolding units for shoring formwork for reinforced concrete slabs and beams. Prefabricated sectional steel

scaffolding sections are as simple to erect for shoring as they are for scaffolding. The same scaffolding components—base plates, adjustable extension legs, welded 5-ft. wide frames varying in height from 3'-0" to 6'-6" and diagonal braces to provide spacing between frames from 2'-6" to 7'-0"—are assembled quickly to provide free standing shoring sections suited to the easy placing of stringers, joists and decking. In most instances, sectional steel shoring can be used wherever conventional shoring methods of adjustable shores or 4"x4" lumber are used, but is especially adaptable for shoring forms for large expanses of flat slab construction.

Height adjustments are quickly made by the use of 20" adjustable legs, which eliminates the need for cutting, fitting and wedging. These legs also facilitate stripping operations by the ease with which the shoring units may be lowered.

Sectional steel shoring also provides scaffolding within the shoring for forming and stripping thereby increasing job safety. This method also minimizes the use of wood reducing the fire hazard and increasing the number of reuses obtainable from form lumber.

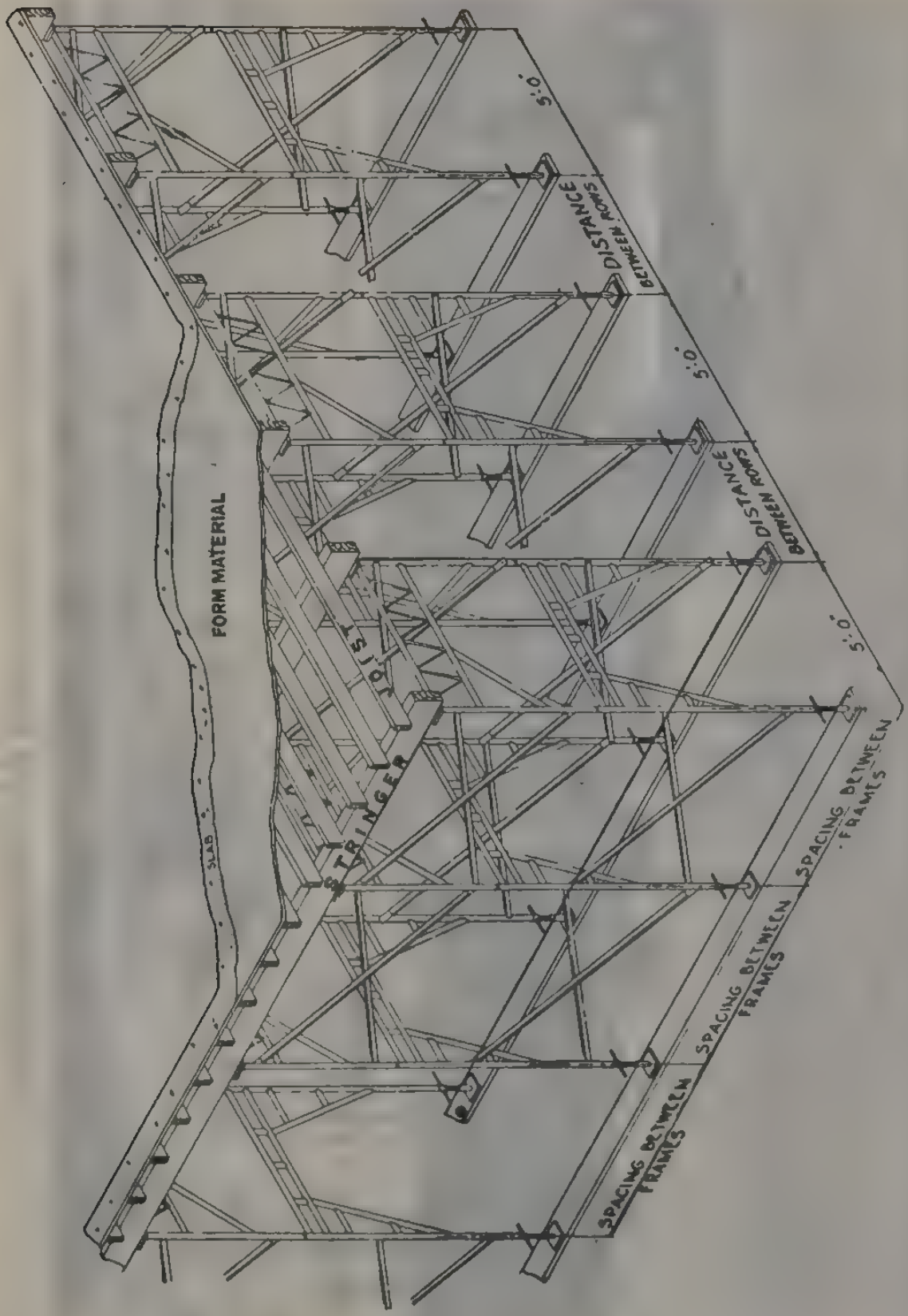
Safe working loads for sectional steel shoring are dependent on the following: (1) spacing between frames in the same row; (2) distance between rows of frames and (3) position of the stringers on the frames. Sectional steel shoring will support the largest loads when the stringers are placed directly over the frame legs by means of inverted base plates or U-heads as may be seen in the illustration. If this is not practicable, stringers should be placed as close as possible to frame legs. If required, additional lateral rigidity may be attained by interlacing frames with standard bracing.

It is available in three types: Standard, 20K Heavy Duty for loads up to 10,000 pounds on each frame leg, and Extra Heavy Duty for loads up to 40,000 pounds on each leg.

The contractor, who does not own this equipment, may rent sectional steel shoring, engineered for a specific job, from the manufacturer on the same basis as scaffolding. This service is available nation-wide.

Since job conditions and requirements vary considerably for different projects, it is practically impossible to give unit labor production values on this method of shoring, but various contractors who have used this method, report savings up to 30 percent in the labor and materials-handling costs over conventional methods. With shoring labor, including bracing, ranging from 15 to 25 percent of the total form cost, this results in overall savings of 4½ to 7½ percent on the entire form cost.

Sectional Shoring Supporting Forms for Concrete Cap of Reservoir



Method of Shoring for Reinforced Concrete Construction Using Sectional Steel Scaffolding Components.

Adjustable Shores for Reinforced Concrete Construction

Adjustable Shores for Reinforced Concrete Floors

There are a number of adjustable shores on the market to support reinforced concrete beam and slab forms. These shores are a combination of wood and metal, or all metal, which can be raised or lowered within certain limits.

Rooshors.*—An adjustable shore in a complete unit, as illustrated. Made in 3 sizes; 8 ft. adjustable to 14 ft.; 7 ft. adjustable to 13 ft.; 5 ft. adjustable to 9 ft.

*Baker-Roos, Inc., Indianapolis, Ind.

They may be purchased at $14.50 for the smaller size and $16.50 for the larger sizes f.o.b. Indianapolis, Ind. Rooshors, Extension Type, are also available in two sizes; 8 ft. adjustable to 14 ft., at $17.75 each; and 6 ft. adjustable to 10 ft. 6 in., at $16.50 each. They can be easily extended by inserting a 4"x4" of any length in the top of the shore.

Rental stocks are maintained in most principal cities and Rooshors may be rented at 60 cts. per month f.o.b. warehouse and return.

Each shore will support about 3,000 lbs. with a good factor of safety. In some cases, however, shores are spaced to carry a load of not over 2,200 lbs., as some forming authorities consider it cheaper to use more shores than to use heavier lumber to prevent excessive deflection between supports.

Adjustable Shores Versus 4"x4"s.—It is much easier to shore up a floor using adjustable shores instead of 4"x4"s, which require wedging and cutting or adding to for each change in story height. This additional labor all costs money at present wage scales. However, to offset this, the original cost of the adjustable shores is much more than the 4"x4"s but if they can be used often enough they will eventually show a saving. This will have to be considered when contemplating a purchase or rental basis.

Another thing that should be considered is the fact that a 4"x4" shore will usually carry a larger load than an adjustable shore, so in many cases it will require more adjustable shores than 4"x4"s to carry the same load. On the other hand, especially on light constructed floors, the adjustable shores may carry all the load required. This is an item that should be considered by the estimator before pricing the job.

The form costs on the following pages are computed on a rental basis, based on 15 days' time for each shore or 2 uses a month.

Labor Cost of Flat Slab Forms.—Forms for flat slab floors are continuous—without breaks or offsets—except at column heads, stair wells, elevator shafts, etc., where it is necessary to frame for beams and girders.

The sq. ft. labor cost will vary with the amount of lumber required per sq. ft. of forms, as the heavier the slab and the higher the ceiling, the more lumber required per sq. ft.

Forms for exceedingly light floor slabs cost proportionately more per sq. ft. than heavy forms as the preliminary work is the same with both types. However, on work of this class a

carpenter should frame and erect 375 to 425 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft:

	Hours	Rate	Total	Rate	Total
Carpenter	20	$.....	$.....	$6.75	$135.00
Labor	10	.....	.....	5.00	50.00
Cost per 1,000 ft. b.m.	30	.....	$.....		$185.00

When removing or "stripping" forms, a laborer should remove 1,000 to 1,200 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Labor	7	$.....	$.....	$5.00	$35.00

Labor Framing for Slab Depressions at Column Heads.—On flat slab jobs there is usually a depression at each column head 5'-0" to 7'-0" square and 4" to 8" deep. The labor cost framing for these depressions will cost about 80 percent more than for straight slab forms.

A satisfactory method of estimating this additional labor is to figure the entire floor area at the regular price and then compute the area of the depressions and figure them at 80 percent additional labor.

Example: Floor contains 10,000 sq. ft. of slab forms, including 40 column head depressions 5'-0"x5'-0", containing 25 sq. ft. each.

10,000 sq. ft. slab forms @ 50 cts. per sq. ft.	$5,000.00
Add for 40 depressions (5'-0"x5'-0") 1,000 sq. ft. at 80% more than plain slab forms or 40 cts. per sq. ft.	400.00

This makes a total of 90 cts. per sq. ft. for labor framing depressions at column heads.

Cost of 100 Sq. Ft. of Flat Slab Concrete Floor Forms Requiring 3 Ft. of Lumber Per Sq. Ft. of Forms

4"x4" Shores	Hours	Rate	Total	Rate	Total
300 ft. lumber		$.....	$.....	$0.06*	$18.00*
Nails, etc.		.....	.....	.01	1.00
Carpenter	7.00	.....	.....	6.75	47.25
Labor	3.50	.....	.....	5.00	17.50
Labor removing forms	2.25	.....	.....	5.00	11.25
Cost per 100 sq. ft.	12.75		$.....		$95.00
Cost per sq. ft.			.....		.950†
Material cost per sq. ft.			.....		.190
Labor cost per sq. ft.			.....		.760†

*Lumber cost based on using each set of forms 3 times.
For story heights over 16'-0", add 25% to labor costs.
†Add for additional labor framing drop heads.

	Adjustable Shores				
	Hours	Rate	Total	Rate	Total
260 ft. lumber.....		$.....	$.....	$0.06*	$15.60*
Nails, etc.		.....	.....	.01	1.00
Rental 5 adjustable shores		.....	.....	.20	1.00
Carpenter	6.00	.....	.....	6.75	33.75
Labor	3.00	.....	.....	5.00	15.00
Labor removing forms..	2.25	.....	.....	5.00	11.25
Cost per 100 sq. ft...	11.25		$.....		$77.60
Cost per sq. ft.....			$.....		.776
Material cost per sq. ft.			.....		.176
Labor cost per sq. ft....			.....		.600

Cost of 100 Sq. Ft. of Flat Slab Forms Requiring 3½ Ft. of Lumber per Sq. Ft.

	4"x4" Shores				
	Hours	Rate	Total	Rate	Total
350 ft. lumber.....		$.....	$.....	$0.06*	$ 21.00*
Nails, etc.		.....	.....	.013	1.30
Carpenter	8.0	.....	.....	6.75	54.00
Labor	4.0	.....	.....	5.00	20.00
Labor removing forms.	2.6	.....	.....	5.00	13.00
Cost per 100 sq. ft....	14.6		$.....		$109.30
Cost per sq. ft.....			.....		1.093
Material cost per sq. ft.			.....		.223
Labor cost per sq. ft...			.....		.870

	Adjustable Shores				
	Hours	Rate	Total	Rate	Total
300 ft. lumber.....		$.....	$.....	$0.06*	$ 18.00*
Nails, etc.		.....	.....	.013	1.30
Rental 5 adjustable shores		.....	.....	.20	1.00
Carpenter	7.0	.....	.....	6.75	33.75
Labor	3.5	.....	.....	5.00	17.50
Labor removing forms.	2.6	.....	.....	5.00	13.00
Cost per 100 sq. ft..	13.10		$.....		$ 84.55
Cost per sq. ft.....			.....		.846
Material cost per sq. ft.			.....		.203
Labor cost per sq. ft....			.....		.643

*Lumber cost based on using each set of forms 3 times.
For story heights over 16'-0", add 25% to labor costs.
†Add for additional labor framing drop heads.

Cost of 100 Sq. Ft. of Flat Slab Forms Requiring 4 Ft. of Lumber Per Sq. Ft.

4"x4" Shores

	Hours	Rate	Total	Rate	Total
400 ft. lumber		$.....	$.....	$0.06*	$ 24.00*
Nails, etc.		.....	.....	.015	1.50
Carpenter	9.0	.....	.....	6.75	60.75
Labor	4.5	.....	.....	5.00	22.50
Labor removing forms	3.0	.....	.....	5.00	15.00
Cost per 100 sq. ft.	16.5		$.....		$123.75
Cost per sq. ft.			.....		1.238†
Material cost per sq. ft.			.....		.255
Labor cost per sq. ft.			.....		.983†

Adjustable Shores

	Hours	Rate	Total	Rate	Total
320 ft. lumber		$.....	$.....	$0.06*	$ 19.20*
Nails, etc.		.....	.....	.015	1.50
Rental 6 adjustable shores		.....	.....	.20	1.20
Carpenter	8.0	.....	.....	6.75	54.00
Labor	4.0	.....	.....	5.00	20.00
Labor removing forms	3.0	.....	.....	5.00	15.00
Cost per 100 sq. ft.	15.0		$.....		$110.90
Cost per sq. ft.			.....		1.109
Material cost per sq. ft.			.....		.219
Labor cost per sq. ft.			.....		.890

Cost of 100 Sq. Ft. of Flat Slab Forms Requiring 4½ Ft. of Lumber Per Sq. Ft.

4"x4" Shores	Hours	Rate	Total	Rate	Total
450 ft. lumber		$.....	$.....	$0.06*	$ 27.00*
Nails, etc.		.....	.....	.018	1.80
Carpenter	11.0	.....	.....	6.75	74.25
Labor	5.5	.....	.....	5.00	27.50
Labor removing forms	3.3	.....	.....	5.00	16.50
Cost per 100 sq. ft.	18.6		$.....		$147.05
Cost per sq. ft.			.....		1.471†
Material cost per sq. ft.			.....		.288
Labor cost per sq. ft.			.....		1.183†

*Lumber cost based on using each set of forms 3 times.
For story heights over 16'-0", add 25% to labor costs.
†Add for additional labor framing drop heads.

Adjustable Shores (Double-Decked)

	Hours	Rate	Total	Rate	Total
360 ft. lumber.....		$.....	$.....	$0.06*	$ 21.60*
Nails, etc.		.....	.....	.018	1.80
Rental 14 adjustable shores		.....	.....	.20	2.80
Carpenter 11.6		.....	.....	6.75	78.30
Labor 5.8		.....	.....	5.00	29.00
Labor removing forms. 4.3		.....	.....	5.00	21.50
Cost per 100 sq. ft...21.7			$.....		$155.00
Cost per sq. ft.....			.....		1.550
Material cost per sq. ft.			.....		.262
Labor cost per sq. ft....			.....		1.288

*Lumber cost based on using each set of forms 3 times. For story heights over 16'-0", add 25% to labor costs.
†Add for additional labor framing drop heads.

Forms for Beam and Girder Type Solid Concrete Floors

The labor cost of wood forms for beam and girder type floors will run somewhat higher than flat slab floors on account of the shorter spans, additional framing around beams, girders, etc.

On forms of this class, a carpenter should frame and erect 325 to 375 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	23.0	$.....	$.....	$6.75	$155.25
Labor	11.5	.....	.....	5.00	57.50
Cost per 1,000 ft. b.m...	34.5		$.....		$212.75

An experienced laborer should remove or "strip" 1,000 to 1,200 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Labor	7	$.....	$....	$5.00	$35.00

Number of Feet of Lumber Required for One Sq. Ft. of Beam and Girder Type Solid Concrete Floor Forms

Ceiling Height in Feet	Thickness of Slab in Inches							
	3" 75 lbs.	4" 88 lbs.	5" 100 lbs	6" 113 lbs	7" 125 lbs.	8" 138 lbs.	10" 163 lbs.	12" 188 lb
10	2.0	2.1	2.4	2.5	2.6	2.6	2.7	2.7
12	2.1	2.2	2.4	2.5	2.6	2.6	2.7	2.8
14	2.1	2.2	2.4	2.5	2.6	2.6	2.7	2.8
16	2.2	2.3	2.5	2.6	2.7	2.7	2.8	2.9
18	2.4	2.5	2.6	2.7	2.8	2.8	2.9	3.0
20	2.5	2.6	2.7	2.8	2.9	2.9	3.0	3.1

Cost of 100 Sq. Ft. of Slab Forms Between Beam and Girder Forms Requiring 2 Ft. of Lumber Per Sq. Ft. of Floor

4"x4" Shores

	Hours	Rate	Total	Rate	Total
200 ft. lumber.....		$.....	$.....	$0.06*	$12.00*
Nails, etc.		.....	.....	.01	1.00
Carpenter	5.0	.....	.....	6.75	33.75
Labor	2.5	.....	.....	5.00	12.50
Labor removing forms..	1.5	.....	.....	5.00	7.50
Cost per 100 sq. ft.....	9.0		$.....		$66.75
Cost per sq. ft.....			.....		.668
Material cost per sq. ft...			.....		.130
Labor cost per sq. ft.....			.....		.538

Adjustable Shores

	Hours	Rate	Total	Rate	Total
165 ft. lumber.....		$.....	$.....	$0.06*	$ 9.90*
Nails, etc.		.....	.....	.01	1.00
Rental 2 adjustable shores		.....	.....	.20	.40
Carpenter	4.6	.....	.....	6.75	31.05
Labor	2.3	.....	.....	5.00	11.50
Labor removing forms..	1.5	.....	.....	5.00	7.50
Cost per 100 sq. ft.....	8.4		$.....		$61.35
Cost per sq. ft.....			.....		.614
Material cost per sq. ft...			.....		.113
Labor cost per sq. ft.....			.....		.501

Cost of 100 Sq. Ft. of Slab Forms Between Beam and Girder Forms Requiring 2½ Ft. of Lumber Per Sq. Ft. of Floor

4"x4" Shores

	Hours	Rate	Total	Rate	Total
250 ft. lumber.....		$.....	$.....	$0.06*	$15.00
Nails, etc.		.....	.....	.01	1.00
Carpenter	6.30	.....	.....	6.75	42.53
Labor	3.15	.....	.....	5.00	15.75
Labor removing forms..	1.90	.....	.....	5.00	9.50
Cost per 100 sq. ft.....	11.35		$.....		$83.78
Cost per sq. ft.....			.....		.838
Material cost per sq. ft...			.....		.160
Labor cost per sq. ft.....			.....		.678

*Lumber cost based on using each set of forms 3 times.
For ceiling heights over 16'-0", add 25% to labor costs.

Adjustable Shores

	Hours	Rate	Total	Rate	Total
220 ft. lumber		$.....	$.....	$0.06*	$13.20*
Nails, etc.		.....	.....	.01	1.00
Rental 3 adjustable shores		.....	.....	.20	.60
Carpenter	5.70	.....	.....	6.75	38.48
Labor	2.85	.....	.....	5.00	14.25
Labor removing forms	1.90	.....	.....	5.00	9.50
Cost per 100 sq. ft.	10.45		$.....		$77.03
Cost per sq. ft.			.....		.770
Material cost per sq. ft.			.....		.148
Labor cost per sq. ft.			.....		.622

Cost of 100 Sq. Ft. of Slab Forms Between Beam and Girde Forms Requiring 3 Ft. of Lumber Per Sq. Ft. of Floor

4"x4" Shores

	Hours	Rate	Total	Rate	Total
300 ft. lumber		$.....	$.....	$0.06*	$18.00*
Nails, etc.		.....	.....	.015	1.50
Carpenter	7.6	.....	.....	6.75	51.30
Labor	3.8	.....	.....	5.00	19.00
Labor removing forms	2.2	.....	.....	5.00	11.00
Cost per 100 sq. ft.	13.6		$.....		$100.80
Cost per sq. ft.			.....		1.00
Material cost per sq. ft.			.....		.19
Labor cost per sq. ft.			.....		.81

Adjustable Shores

	Hours	Rate	Total	Rate	Total
250 ft. lumber		$.....	$.....	$0.06*	$15.00
Nails, etc.		.....	.....	.01	1.00
Rental 4 adjustable shores		.....	.....	.20	.80
Carpenter	6.8	.....	.....	6.75	45.90
Labor	3.4	.....	.....	5.00	17.00
Labor removing forms	2.2	.....	.....	5.00	11.00
Cost per 100 sq. ft.	12.4		$.....		$ 90.70
Cost per sq. ft.			.....		.90
Material cost per sq. ft.			.....		.16
Labor cost per sq. ft.			.....		.73

*Lumber cost based on using each set of forms 3 times. For story heights over 16'-0", add 25% to labor costs.

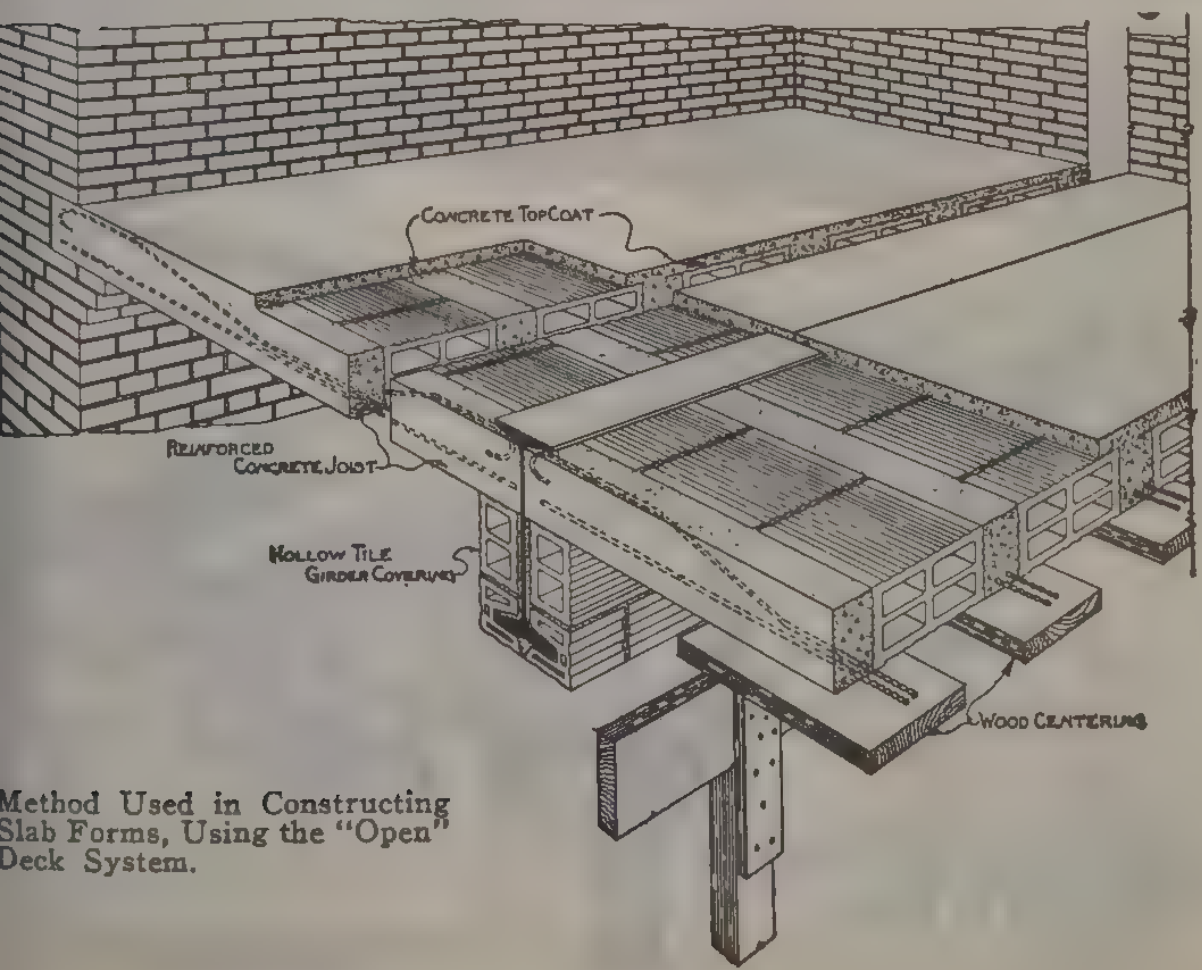
Forms for Floors of Combination Clay Tile and Concrete Joist Construction

Wood forms for this type of floor are much lighter than those required for solid concrete floors because of the reduced dead load, due to the lighter weight of clay tile over concrete.

Forms for floors of this type may be either "open" or "closed" deck construction. Some contractors erect the forms in the usual way and cover the entire slab area with 1" sheathing. This is known as "closed" deck construction. The "open" deck method uses 2"x8" plank spaced about 8" apart, which allows for a 2" bearing for the tile and the usual 4" or 5" concrete joist.

When using "open" deck construction, care must be exercised to space the planks accurately so the tile will have sufficient bearing on the forms. This is not necessary where the floor is sheathed solid and for that reason the labor costs on "closed" deck construction are a trifle less than the "open" deck but there is more salvage value in the 2" lumber than in 1".

Where "open" deck forms are used there is usually consider-



Method Used in Constructing Slab Forms, Using the "Open" Deck System.

able loss of cement grout due to the open spaces between the clay tile and the floor boards, whereas this is overcome when the deck is sheathed solid. However, the "open" deck construction is more commonly used.

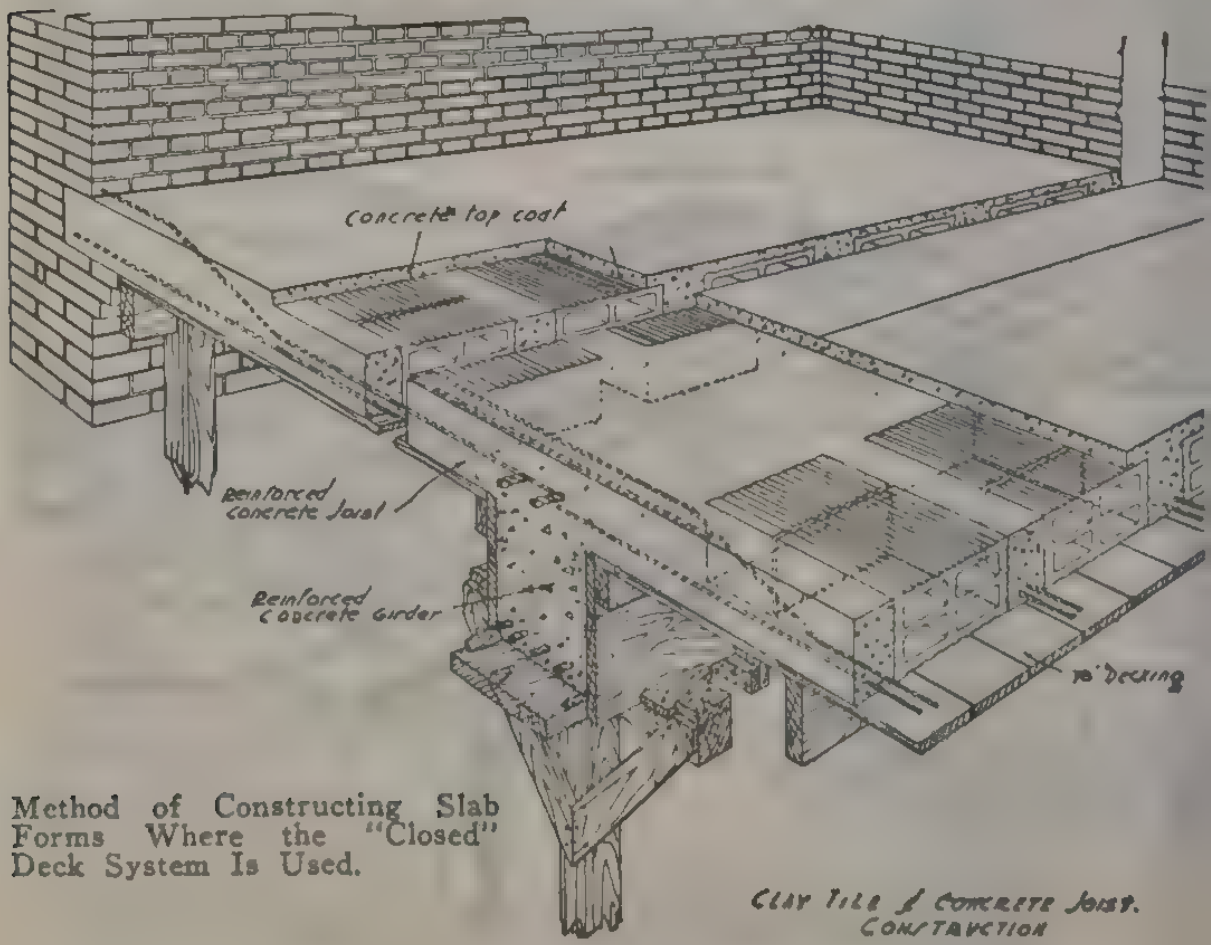
On jobs having long floor spans with beams and girders running in only one direction, one carpenter should frame and erect 350 to 400 ft. of lumber per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	21.4	$.....	$.....	$6.75	$144.45
Labor	10.7	.....	.....	5.00	53.50
Cost per 1,000 ft. b.m.	32.1		$.....		$197.95

An experienced laborer should remove or "strip" 1,000 to 1,200 ft. of lumber per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Labor	7	$.....	$.....	$5.00	$35.00

On jobs having beams and girders running in both directions with average size of floor panels 16'-0"x16'-0" and smaller, figure



Method of Constructing Slab Forms Where the "Closed" Deck System Is Used.

form costs the same as given for "Beam and Girder Type Solid Concrete Floor Forms," on the previous pages.

Weight of Combination Clay Tile and Concrete Joist Floors

Based on concrete joists 4" wide, 16" on centers, with a 2½" concrete slab on top.

Concrete Thickness, Inches	2½"	2½"	2½"	2½"	2½"
Tile Thickness, Inches	4"	6"	8"	10"	12"
Total Slab Thickness, Inches	6½"	8½"	10½"	12½"	14½"
Weight of Slab per Sq. Ft. Lbs.	57	69	80	90	104
Temporary Dead and Live Load, per Sq. Ft.	38	38	38	38	38
Total Load on Forms per Sq. Ft.	95	107	118	128	142

Number of Feet of Lumber Required for One Sq. Ft. of Floor Forms for Clay Tile and Concrete Joist Construction

The following table is based on the assumption the ends of joists and stringers are supported by the beam and girder forms and on using yellow pine, Douglas fir or woods of equal strength.

Ceiling Height in Feet	Thickness of Floor Slab in Inches				
	6½" 95 lbs.	8½" 107 lbs.	10½" 118 lbs.	12½" 128 lbs.	14½" 142 lbs.
10	2.3	2.4	2.5	2.6	2.6
12	2.4	2.5	2.6	2.6	2.7
14	2.4	2.5	2.6	2.6	2.7
16	2.5	2.6	2.7	2.7	2.8
18	2.6	2.7	2.8	2.8	2.9
20	2.7	2.8	2.9	2.9	3.0

Feet of Lumber Required for One Sq. Ft. of Floor Forms for Clay Tile and Concrete Joist Construction

The following table is based on the assumption it is a wall bearing job and will require wood girts or stringers together with supporting shores at both ends of joists and stringers.

Ceiling Height in Feet	Thickness of Floor Slab in Inches				
	6½" 95 lbs.	8½" 107 lbs.	10½" 118 lbs.	12½" 128 lbs.	14½" 142 lbs.
10	2.8	2.9	3.0	3.1	3.1
12	2.8	2.9	3.0	3.1	3.1
14	2.9	3.0	3.1	3.2	3.2
16	2.9	3.0	3.1	3.2	3.2
18	3.2	3.3	3.4	3.5	3.5
20	3.2	3.3	3.4	3.5	3.5

Cost of 100 Sq. Ft. of Clay Tile and Concrete Joist Slab Forms Requiring 2¾ Ft. of Lumber Per Sq. Ft.

Long spans and 1-way beams. For short spans and 2-way beams, figure same as "Beam and Girder Type Solid Concrete Floors."

4"x4" Shores	Hours	Rate	Total	Rate	Total
275 ft. lumber		$.....	$.....	$0.06*	$16.50*
Nails, etc.		.....	.....	.01	1.00
Carpenter	6.6	.....	.....	6.75	44.55
Labor	3.3	.....	.....	5.00	16.50
Labor removing forms	2.0	.....	.....	5.00	10.00
Cost per 100 sq. ft.	11.9		$.....		$88.55
Cost per sq. ft.			.....		.886
Material cost per sq. ft.			.....		.175
Labor cost per sq. ft.			.....		.711

Adjustable Shores	Hours	Rate	Total	Rate	Total
240 ft. lumber		$.....	.....	$0.06*	$14.40*
Nails, etc.		.....	.....	.01	1.00
Rental 4 adjustable shores		.....	.....	.20	.80
Carpenter	5.8	.....	.....	6.75	39.15
Labor	2.9	.....	.....	5.00	14.50
Labor removing forms	2.0	.....	.....	5.00	10.00
Cost per 100 sq. ft.	10.7		$.....		$79.85
Cost per sq. ft.			.....		.799
Material cost per sq. ft.			.....		.162
Labor cost per sq. ft.			.....		.637

Cost of 100 Sq. Ft. of Clay Tile and Concrete Joist Slab Form Requiring 3 Ft. of Lumber Per Sq. Ft.

Long spans and 1-way beams. For short spans and 2-way beams figure same as "Beam and Girder Type Solid Concrete Floors.

4"x4" Shores	Hours	Rate	Total	Rate	Total
300 ft. lumber		$.....	$.....	$0.06*	$18.00*
Nails, etc.		.....	.....	.01	1.00
Carpenter	7.2	.....	.....	6.75	48.60
Labor	3.6	.....	.....	5.00	18.00
Labor removing forms	2.2	.....	.....	5.00	11.00
Cost per 100 sq. ft.	13.0		$.....		$96.60
Cost per sq. ft.			.....		.966
Material cost per sq. ft.			.....		.190
Labor cost per sq. ft.			.....		.776

*Lumber cost based on using each set of forms 3 times.
For ceiling heights over 16'-0", add 25% to labor costs.

Adjustable Shores	Hours	Rate	Total	Rate	Total
250 ft. lumber		$.....	$.....	$0.06*	$15.00*
Nails, etc.				.01	1.00
Rental 4 adjustable shores				.20	.80
Carpenter	6.4			6.75	43.20
Labor	3.2			5.00	16.00
Labor removing forms	2.2			5.00	11.00
Cost per 100 sq. ft.	11.8		$.....		$87.00
Cost per sq. ft.					.870
Material cost per sq. ft.					.168
Labor cost per sq. ft.					.702

Cost of 100 Sq. Ft. of Clay Tile and Concrete Joist Slab Forms Requiring 3½ Ft. of Lumber Per Sq. Ft.

Long spans and 1-way beams. For short spans and 2-way beams figure same as "Beam and Girder Type Solid Concrete Floors."

4"x4" Shores	Hours	Rate	Total	Rate	Total
350 ft. lumber		$.....	$.....	$0.06*	$ 21.00*
Nails, etc.				.013	1.30
Carpenter	8.2			6.75	55.35
Labor	4.1			5.00	20.50
Labor removing forms	2.5			5.00	12.50
Cost per 100 sq. ft.	14.8		$.....		$110.65
Cost per sq. ft.					1.107
Material cost per sq. ft.					.223
Labor cost per sq. ft.					.884

Cost of 100 Sq. Ft. of Clay Tile and Concrete Joist Slab Forms Requiring 3½ Ft. of Lumber Per Sq. Ft.

Adjustable Shores	Hours	Rate	Total	Rate	Total
300 ft. lumber		$.....	$.....	$0.06*	$ 18.00*
Nails, etc.				.01	1.00
Rental 4 adjustable shores				.20	.80
Carpenter	7.4			6.75	49.95
Labor	3.7			5.00	18.50
Labor removing forms	2.5			5.00	12.50
Cost per 100 sq. ft.	13.6		$.....		$100.75
Cost per sq. ft.					1.008
Material cost per sq. ft.					.198
Labor cost per sq. ft.					.810

*Lumber cost based on using each set of forms 3 times.
For ceiling heights over 16'-0", add 25% to labor costs.

Forms for Floors of Metal Pan and Concrete Joist Construction

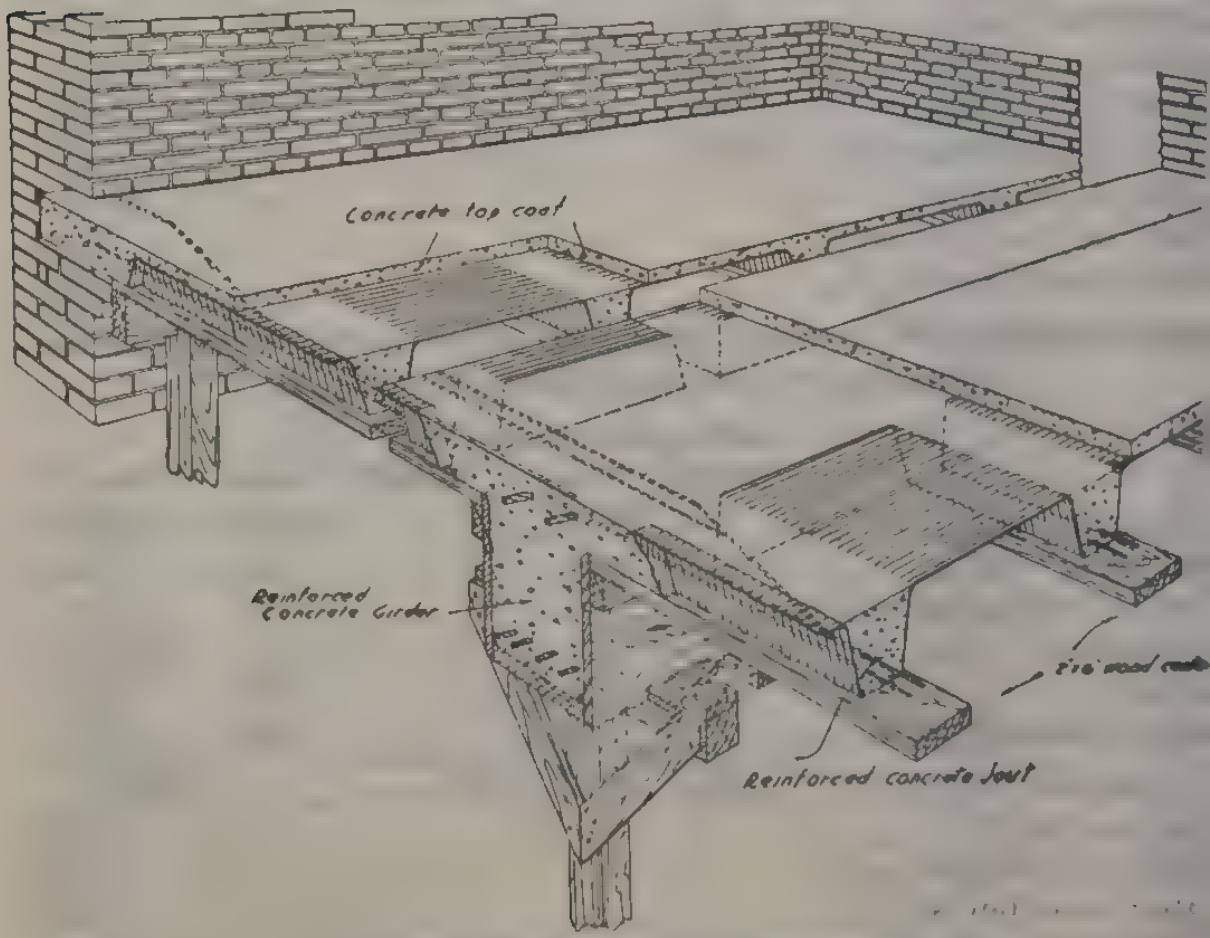
Wood forms for floors of metal pan and concrete joist construction may be of much lighter construction than either solid concrete or clay tile and concrete joist floors, as the dead load is less.

Metal pans are usually furnished 20" to 30" wide, with 2"x6" or 2"x8" plank spaced 24" to 37" on centers, depending upon the width of the joists, which vary from 4" to 7".

The open deck construction is ordinarily used owing to the wide spacing of the floor boards.

In buildings having one-way beams and long floor spans, a carpenter should frame and erect 350 to 400 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	21.4	$.....	$.....	$6.75	$144.45
Labor	10.7	.....	.....	5.00	53.50
Cost per 1,000 ft. b.m.	32.1		$.....		$197.95



Method of Constructing Wood Slab Forms for Floors of Metal Pans and Concrete Joist Construction

Floors having beams and girders running in both directions with the floor panels averaging 16'-0"x16'-0" and smaller, a carpenter should frame and erect 325 to 375 ft. of lumber per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	22.8	$.....	$.....	$6.75	$153.90
Labor	11.4	.....	.....	5.00	57.00
Cost per 1,000 ft. b.m.	34.2		$.....		$210.90

An experienced laborer should remove or strip 1,000 to 1,200 ft. of lumber per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Labor	7	$.....	$.....	$5.00	$35.00

Number of Feet of Lumber Required for One Sq. Ft. of Floor Forms for Metal Pan and Concrete Joist Construction

The following table is based on the assumption the ends of joists and stringers are supported by the beam and girder forms.

Ceiling Height in Feet	Thickness of Floor Slab in Inches 8½" 85 lbs.	10½" 90 lbs.	12½" 100 lbs.	14½" 105 lbs.	16½" 115 lbs.
10	1.7	1.7	1.7	1.8	1.8
12	1.7	1.7	1.8	1.9	1.9
14	1.7	1.7	1.8	1.9	2.0
16	1.8	1.8	1.9	2.0	2.1
18	2.1	2.1	2.2	2.3	2.4
20	2.2	2.2	2.3	2.4	2.5

Number of Feet of Lumber Required for One Sq. Ft. of Floor Forms for Metal Pan and Concrete Joist Construction

The following table is based on the assumption it is a wall bearing job and will require wood girts or stringers together with supporting shores at both ends of joists and stringers.

Ceiling Height in Feet	Thickness of Floor Slab in Inches 8½" 85 lbs.	10½" 90 lbs.	12½" 100 lbs.	14½" 105 lbs.	16½" 115 lbs.
10	2.1	2.1	2.1	2.2	2.2
12	2.1	2.1	2.1	2.2	2.2
14	2.2	2.2	2.2	2.3	2.4
16	2.3	2.3	2.3	2.4	2.4
18	2.5	2.5	2.6	2.7	2.8
20	2.6	2.6	2.7	2.8	2.9

Using Yellow pine, Douglas fir, or woods of equal strength.

Cost of 100 Sq. Ft. of Metal Pan and Concrete Joist Slab Forms Requiring 1¾ Ft. of Lumber Per Sq. Ft.

Long spans and 1-way beams. For short spans and 2-way beams, add 10% to labor costs.

4"x4" Shores	Hours	Rate	Total	Rate	Total
175 ft. lumber		$.....	$.....	$0.060*	$10.50*
Nails, etc.		.....	.....	.01	1.00
Carpenter	4.2	.....	.....	6.75	28.35
Labor	2.1	.....	.....	5.00	10.50
Labor removing forms	1.3	.....	.....	5.00	6.50
Cost per 100 sq. ft.	7.6		$.....		$56.85
Cost per sq. ft.			.....		.569
Material cost per sq. ft.			.....		.115
Labor cost per sq. ft.			.....		.454

Adjustable Shores	Hours	Rate	Total	Rate	Total
140 ft. lumber		$.....	$.....	$0.060*	$ 8.40*
Nails, etc.		.....	.....	.01	1.00
Rental 2 adjustable shores		.....	.....	.25	.50
Carpenter	3.8	.....	.....	6.75	25.65
Labor	1.9	.....	.....	5.00	9.50
Labor removing forms	1.3	.....	.....	5.00	6.50
Cost per 100 sq. ft.	7.0	.....	$.....		$51.55
Cost per sq. ft.			.....		.51
Material cost per sq. ft.			.....		.09
Labor cost per sq. ft.			.....		.41

Cost of 100 Sq. Ft. of Metal Pan and Concrete Joist Slab Forms Requiring 2 Ft. of Lumber Per Sq. Ft.

Long spans and 1-way beams. For short spans and 2-way beams, add 10% to labor costs.

4"x4" Shores	Hours	Rate	Total	Rate	Total
200 ft. lumber		$.....	$.....	$0.060*	$12.00
Nails, etc.		.....	.....	.01	1.00
Carpenter	4.90	.....	.....	6.75	33.08
Labor	2.45	.....	.....	5.00	12.25
Labor removing forms	1.50	.....	.....	5.00	7.50
Cost per 100 sq. ft.	8.85		$.....		$65.83
Cost per sq. ft.			.....		.65
Material cost per sq. ft.			.....		.13
Labor cost per sq. ft.			.....		.52

*Lumber cost based on using each set of forms 3 times.
For story heights over 16'-0", add 25% to labor costs.

Adjustable Shores

	Hours	Rate	Total	Rate	Total
165 ft. lumber		$.....	$.....	$0.060*	$ 9.90*
Nails, etc.		.....	.....	.01	1.00
Rental 3 adjustable shores		.....	.....	.25	.75
Carpenter	4.30	.....	.....	6.75	29.03
Labor	2.15	.....	.....	5.00	10.75
Labor removing forms	1.50	.....	.....	5.00	7.50
Cost per 100 sq. ft.	7.95		$.....		$58.93
Cost per sq. ft.			.....		.589
Material cost per sq. ft.			.....		.117
Labor cost per sq. ft.			.....		.472

Cost of 100 Sq. Ft. of Metal Pan and Concrete Joist Slab Forms Requiring 2½ Ft. of Lumber Per Sq. Ft.

4"x4" Shores

	Hours	Rate	Total	Rate	Total
250 ft. lumber		$.....	$.....	$0.060*	$15.00*
Nails, etc.		.....	.....	.01	1.00
Carpenter	6.0	.....	.....	6.75	40.50
Labor	3.0	.....	.....	5.00	15.00
Labor removing forms	1.8	.....	.....	5.00	9.00
Cost per 100 sq. ft.	10.8		$.....		$80.50
Cost per sq. ft.			.....		.805
Material cost per sq. ft.			.....		.160
Labor cost per sq. ft.			.....		.645

Adjustable Shores

	Hours	Rate	Total	Rate	Total
215 ft. lumber		$.....	$.....	$0.060*	$12.90*
Nails, etc.		.....	.....	.01	1.00
Rental 3 adjustable shores		.....	.....	.25	.75
Carpenter	5.4	.....	.....	6.75	36.45
Labor	2.7	.....	.....	5.00	13.50
Labor removing forms	1.8	.....	.....	5.00	9.00
Cost per 100 sq. ft.	9.9		$.....		$73.60
Cost per sq. ft.			.....		.736
Material cost per sq. ft.			.....		.147
Labor cost per sq. ft.			.....		.589

*Lumber cost based on using each set of forms 3 times.

For story heights over 16'-0", add 25% to labor costs.

Cost of 100 Sq. Ft. of Metal Pan and Concrete Joist Slab Forms Requiring 3 Ft. of Lumber Per Sq. Ft.

4"x4" Shores

	Hours	Rate	Total	Rate	Total
300 ft. lumber		$.....	$.....	$0.060*	$18.00*
Nails, etc.		.....	.....	.01	1.00
Carpenter	7.0	.....	.....	6.75	47.25
Labor	3.5	.....	.....	5.00	17.50
Labor removing forms	2.2	.....	.....	5.00	11.00
Cost per 100 sq. ft.	12.7		$.....		$94.75
Cost per sq. ft.			.....		.948
Material cost per sq. ft.			.....		.190
Labor cost per sq. ft.			.....		.758

*Lumber cost based on using each set of forms 3 times. For story heights over 16'-0", add 25% to labor costs.

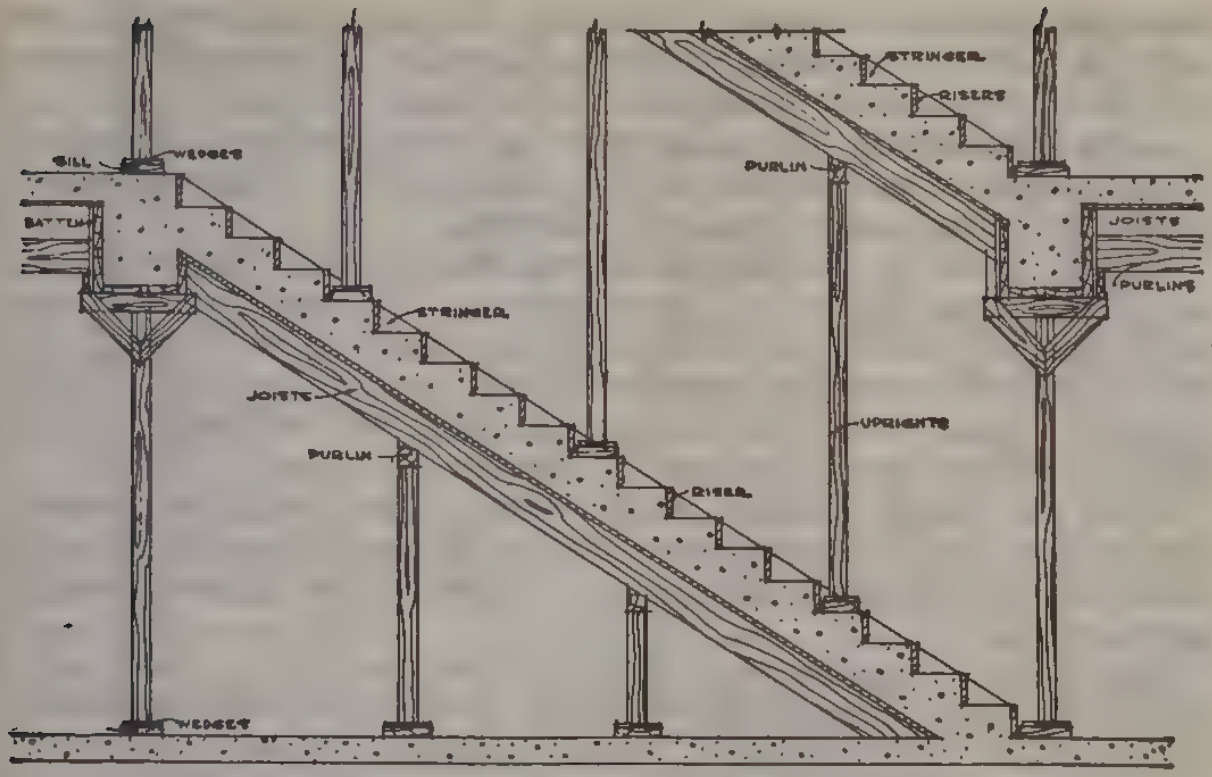
Adjustable Shores

	Hours	Rate	Total	Rate	Total
260 ft. lumber		$.....	$.....	$0.060*	$15.60*
Nails, etc.		.....	.....	.01	1.00
Rental 3 adjustable shores		.....	.....	.25	.75
Carpenter	6.4	.....	.....	6.75	43.20
Labor	3.2	.....	.....	5.00	16.00
Labor removing forms	2.2	.....	.....	5.00	11.00
Cost per 100 sq. ft.	11.8		$.....		$87.55
Cost per sq. ft.			.....		.876
Material cost per sq. ft.			.....		.174
Labor cost per sq. ft.			.....		.702

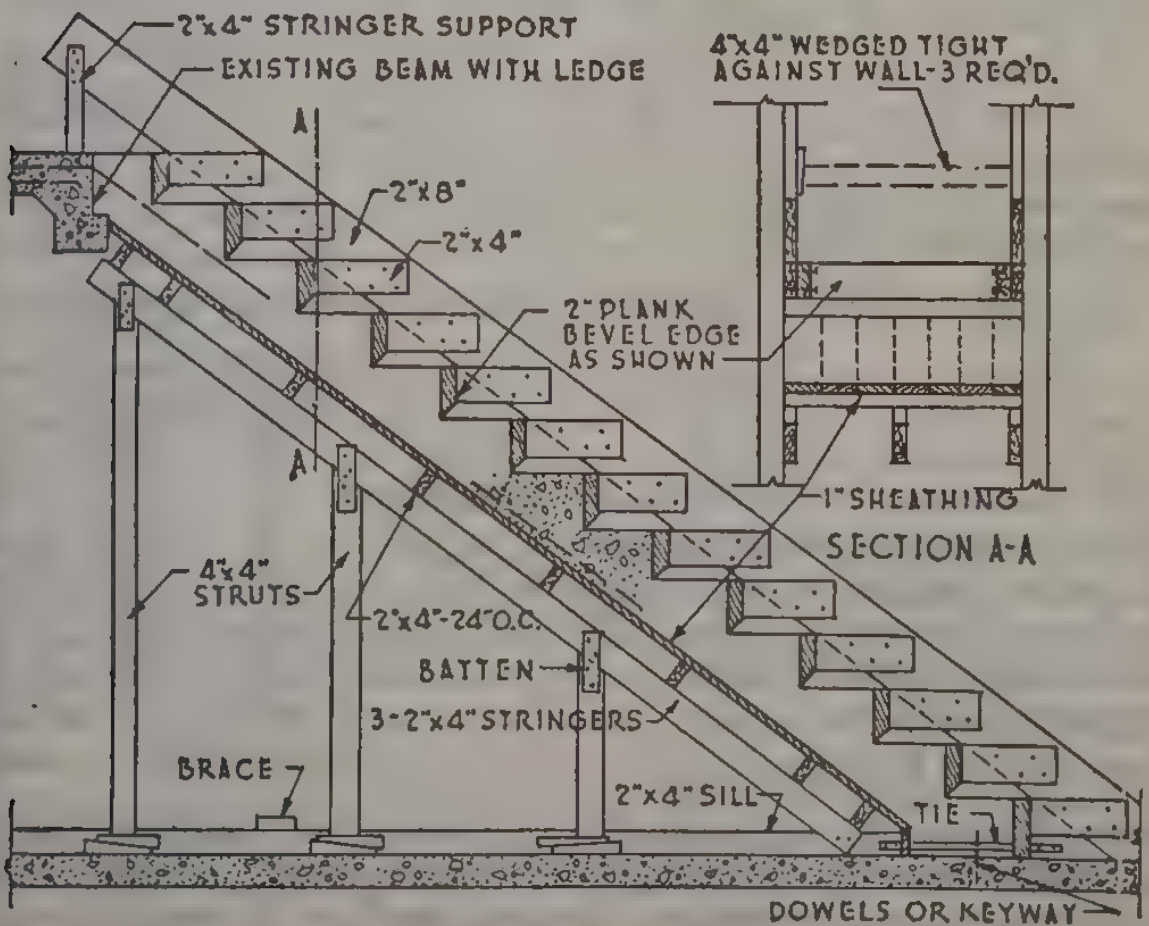
FORMS FOR REINFORCED CONCRETE STAIRS

The labor cost of framing and erecting concrete stair forms will vary with the type of stair, whether open or box string, straight runs from floor to floor or having intermediate landing platforms. Also, whether the stair is straight or winding and having square or bull nose treads and risers. The story height will also affect the labor costs on account of the shoring and bracing necessary to support the wet concrete.

It is rather difficult to estimate the cost of stair forms on a sq. ft. basis as it costs as much to frame a 3'-0" stair as one 4'-0" wide, while the latter contains one-third more forms per lin. ft. The better method is to allow a certain price per flight of stairs of each type as this will result in more accurate estimates than the sq. ft. method. However, where it is desirable to



Method of Constructing Wood Forms for Concrete Stairs



Another Method of Constructing Wood Forms for Concrete Stairs.

estimate the stair forms by the sq. ft. take the area of the soffit of the stairs and platforms. Example: a stair 4'-0" wide and 18'-0" long, contains 72 sq. ft. of forms.

Some contractors and estimators estimate the cost of stairs at a certain price per lin. ft. of riser, which includes forms, reinforcing steel, concrete and finishing.

Wood Forms for Straight Concrete Stairs.—On straight stairs extending from floor to floor without intermediate landing platforms and having an average story height of 10'-0" to 12'-0", two carpenters working together should lay out the stair, place rough stringers, mark off treads and risers on the rough string boards and set them in place in about 8 to 9 hours.

After the rough strings are in place it will require another 8 to 10 hrs. for 2 carpenters to sheath the stairs, cut, bevel and place risers, and place all necessary shoring and bracing ready for concrete.

The forms for an average flight of concrete stairs, 4'-0" wide and 18'-0" long, containing 72 sq. ft. of forms (soffit measurement) or 72 lin. ft. of risers, should cost as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	36	$.....	$.....	$6.75	$243.00
Labor helping and removing forms	9	.....	.....	5.00	45.00
Cost per flight	45		$.....		$288.00
Cost per sq. ft.			.....		4.00
Cost per lin. ft. riser			.....		4.00
Cost per riser (18)			.....		16.00

The lumber cost for this stair should run about as follows:

	Ft. B.M.	Rate	Total
Stringers, 2 pcs. 2"x12"-20'-0"	80	$0.150	$12.00
Risers, 18 pcs. 2"x8"-4'-0"	96	.150	14.40
Soffit sheathing, 4'-0"x18'-0", plus 20% waste	87	.135	11.58
Joists supporting sheathing, 4 pcs. 2"x8"-18'-0"	96	.150	14.40
Shores or uprights, 6 pcs. 4"x4" 10'-0"	80	.180	14.40
Purlins or stringers, 3 pcs. 4"x6"-4'-0"	24	.180	4.32
Sills, wedges and bracing	30	.150	4.50
Cost per flight	493		$75.60
Cost per sq. ft. (72)	6.85		1.05

Wood Forms for Concrete Stairs Having Intermediate Landing Platforms.—Where the concrete stairs consist of two short flights with an intermediate landing platform between floors,

the labor cost per story will run somewhat higher than for straight run stairs, on account of laying out and framing for two short flights instead of one long one.

Stairs of this type up to 4′-0″ wide and 8′-0″ to 10′-0″ long from floor to platform, with each short flight containing 36 to 40 sq. ft. of forms (soffit measurement), and 8 to 10 risers, should cost about as follows for labor:

	Hours	Rate	Total	Rate	Total
Carpenter	23	$.....	$.....	$6.75	$155.25
Labor helping and removing forms	7	.....	.....	5.00	35.00
Cost per flight	30		$.....		$190.25
Cost per sq. ft. (36)					5.29
Cost per lin. ft. riser (36)					5.29
Cost per riser (9)					21.16

If the stairs are built between masonry walls and have their bearing in slots or chases left in the wall, it will require about 2 hrs. additional carpenter time cutting out stringers, if using a hand saw or ½ to ¾-hr. if using a power saw.

Winding stairs, stairs having bull nose treads and risers and other difficult or complicated construction may cost 2 or 3 times as much as given above. The estimator will have to use his judgment, depending upon detail of the stair.

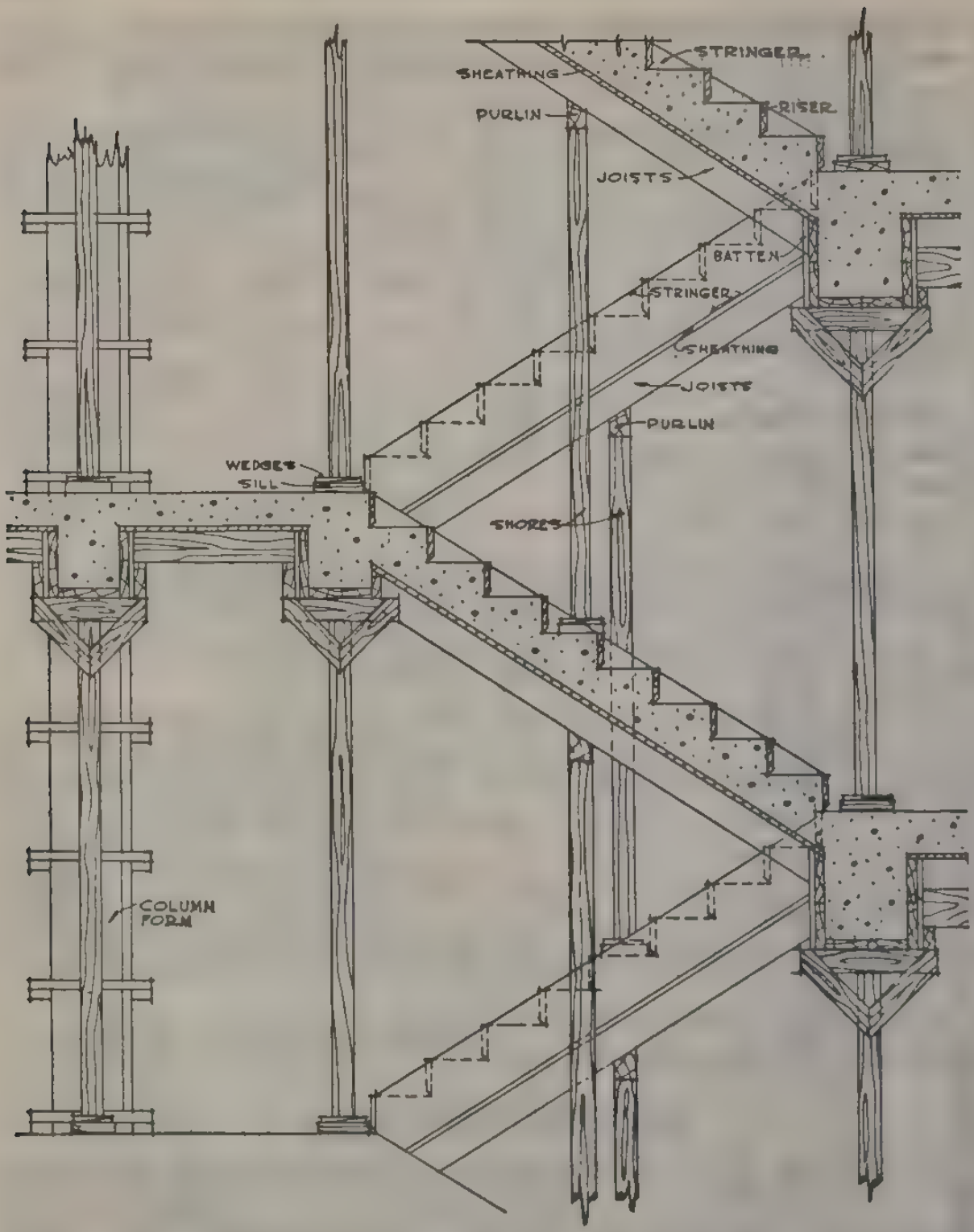
When erecting formwork for concrete stairs over 4′-0″ wide, it will be necessary to place additional "cut-out" stringers, to prevent the risers from bulging or giving way until the wet concrete has set. These "cut-out" stringers should be spaced 3′-0″ to 4′-0″ apart.

When figuring labor costs of landing platforms, double the labor cost of plain slab forms.

REINFORCING STEEL

Reinforcing steel is estimated by weight, obtained by listing all bars of different sizes and lengths and reducing the total to pounds. Reinforcing bars may be purchased from warehouse in stock lengths and all cutting and bending done on the job or it may be purchased cut to length and bent, ready to place in the building.

When purchased in stock lengths, the labor cost of unloading sorting, handling and storing is less than where sent to the job cut to length and bent. The former method requires less storage space as the different size stock length bars are placed



Method of Constructing Wood Forms for Concrete Stairs Having Intermediate Platforms

in compact piles, while steel cut to length and bent requires considerable storage space as all bars of each size and length must be placed in separate piles.

While it costs more to handle and store steel sent to the job cut to length and bent, the shop costs of cutting and bending

are much less than the job costs, especially where the work is done by iron workers at present day wages. Practically all reinforcing steel used today is shop fabricated, i.e., cut to length and bent prior to delivery to the job site.

There has been considerable change in reinforcing bar design in recent years, with more steel going into the deformations and a trifle less into the bar proper. The total weight of the bars remains the same as previously but the actual diameter of the bar is slightly less.

For this reason, instead of calling the bars ½", ¾", etc., they now are known as No. 3, 4, 5, 6, etc.

The following tables gives the bar classifications:

Standard Sizes and Weights of Concrete Reinforcing Bars

Bar Designation (Numbers)	Unit Weight Pounds per Foot	Nominal Dimensions,—Round Sections Inches Diameter	Cross Sectional area Square Inches	Perimeter Inches
2	0.167	.250	0.05	0.786
3	0.376	.375	0.11	1.178
4	0.668	.500	0.20	1.571
5	1.043	.625	0.31	1.963
6	1.502	.750	0.44	2.356
7	2.044	.875	0.60	2.749
8	2.670	1.000	0.79	3.142
9	3.400	1.128	1.00	3.544
10	4.303	1.270	1.27	3.990
11	5.313	1.410	1.56	4.430
14S	7.650	1.693	2.25	5.320
18S	13.600	2.257	4.00	7.090

Bar No. 2 in plain rounds only.

Basis for Estimating Price of Reinforcing Steel.—When estimating quantities and weights of reinforcing steel, all bars of each size should be listed separately to obtain the correct weight. No. 6 bars and over take the lowest price per lb. while bars smaller than No. 6 increase in price on a graduated scale depending upon the size of the bars. The smaller the bars the higher the price per lb.

Example: If base price is $6.90 per 100 lbs. what is price of No. 3 bars? The table shows that No. 3 bars take an increase of $1.40 per 100 lbs. over base or $8.30 per 100 lbs.

Prices are usually quoted f.o.b. warehouse, with freight allowed to destination.

Extras on Reinforcing Bars

Number	Extra per 100 lbs.
14S and 18S	$1.50*
6 to 11	0.50
5	0.70
4	1.00
3	1.40
2	2.50

* Includes cutting extra

Prices on rail steel are theoretically the same as for billet steel but will vary with the scrap market on rails.

There are three specifications covering the use of reinforcing steel. A.S.T.M. designation A305, the Standard Specification for Deformed Reinforcing Bars, defines the type of bar; A.S.T.M. 15 and A.S.T.M. 16 defines the type of steel from which they may be rolled.

Two widely used standard grades of reinforcement are available in American and Canadian markets. Billet Steel (A.S.T.M. Specifications A15) and Rail Steel (A.S.T.M. Specifications A16) the latter being rolled from rails of high carbon steel which have been slit into 3 longitudinal bars by a special machine.

Both grades are standard in building codes and in the design recommendations of the American Concrete Institute.

Quantity Extras.—In addition to the base price of steel there is a quantity extra, based on the number of tons of steel in the job, as follows:

	Add per 100 lbs.
40,000 lbs. and over	Base—no extra
30,000 to 39,999	$0.25
20,000 to 29,999	0.35
10,000 to 19,999	0.50
6,000 to 9,999	0.75
2,000 to 5,999	1.50
Under 2,000	2.00

Bending Reinforcing Steel.—The labor cost of bending reinforcing bars will vary with the size of the bars and the amount of bending necessary; the lighter the bars the higher the bending cost per ton.

Type L Bending.—Bending all No. 2 and No. 3 bars; all No. 4 stirrups and column ties; truss bars and all sizes of bars bent at more than 6 points. It also includes all bars bent in more than one plane and all radius bending with more than one radius in any bar $2.20 per 100 lbs. or $44.00 per ton.

Type H Bending.—Bending truss bars for beams and slabs, ther than No. 2 and No. 3, radius bending and types not otherwise escribed, $0.90 per 100 lbs. or 18.00 per ton.

When cut is made by means other than sawing or milling, $.05 er end.

When cut is made by sawing or milling, $.15 per end.

Weights are in pounds per foot of height exclusive of spacers and ends

Spirals above the stepped line are not collapsible for shipment

1 Spirals are sold on the basis of theoretical weights

2 F = Weight to Add for Finishing (This includes 1½ turns at top and 1½ turns at bottom of spiral ACI 318-56.) Total Wt. = (Wt. per Ft. × Height) + (F) + Wt. of Spacers

3 Two spacers are required for Spirals 20" or less in diameter, 3 spacers for Spirals 20 to 30", and 4 spacers for Spirals over 30" in diameter and for ALL ⅝" or larger spiral rods, regardless of spiral diameter. Allow ¾ pound per lin. ft. per spacer

4 The four spiral rod sizes shown in the table have been approved by the U. S. Department of Commerce Simplified Practice Recommendation R53 and are carried in stock ready for fabrication

Spirals for Reinforced Concrete Columns.—Spirals shou always be coiled and fabricated in the shop as it is all machi work.

Prices of spirals vary throughout the country in the sa manner and for the same reasons as reinforcing steel. Quant extras are figured independently of reinforcing steel tonna involved.

At the present time, prices of fabricated spirals in the Chica area, including installation of spacer, are as follows:

Quantity	¼" Dia.	⅜" Dia.	½" Dia.	⅝" D
40,000 lbs. and over	$13.41	$12.31	$11.91	$11
30,000 to 39,999	13.66	12.56	12.16	11
20,000 to 29,999	13.76	12.66	12.26	11
10,000 to 19,999	13.91	12.81	12.41	12
6,000 to 9,999	14.16	13.06	12.66	12
2,000 to 5,999	14.91	13.81	13.41	13
Under 2,000	15.41	14.31	13.91	13

All prices are in dollars per 100 lbs.

Extra for cold drawn wire, $1.50 per 100 lbs., or $30.00 per t Without Spacers, deduct $0.50 per 100 lbs. or $10.00 per t

Cost of Engineering Service.—The cost of making worki drawings, bending details, setting plans, etc., will vary with amount of work involved.

Where the engineers prepare the complete design for a inforced concrete structure, including working drawings, plac plans, bar lists and bending details, add 60 cts. per 100 lbs. $12 per ton to the detailing charges given below.

For preparing order lists with or without bending deta from plans on which all sizes and lengths are shown by othe $0.15 per 100 lbs. or $3.00 per ton.

Minimum charge for any engineering work is $25.

Detailing and placing plans from designs made by othe cost as follows:

	Price per 100 lbs.	Maximum Charge
Less than 5 tons	$1.00	$ 85.00
5 to 19.99	.85	300.00
20 to 74.99	.75	975.00
75 to 199.99	.65	2,000.00
200 to 499.99	.50	4,500.00
500 and over	.45	None

Hauling Reinforcing Bars From Shops or Cars to Job.—T cost of hauling reinforcing steel from warehouse to job w vary with the distance of the haul and the size of the ci

For example, in the Chicago area, the trucking charge deliveries within city limits is 30 cts. per cwt.; for jobs locat

n the Chicago suburbs, the trucking charge is 40 cts. per cwt. Minimum charge for both zones is $5.00.

Unloading Reinforcing Steel From Cars or Trucks.—If steel an be unloaded direct from cars or trucks, without sorting or arrying to stock piles, a man will unload 4½ to 5½ tons per 8-hr. ay, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
abor	1.75	$.....	$.....	$5.00	$8.75

If necessary to carry the bars up to 50 ft. sort and place in tock piles, figure 2½ to 3 tons per 8-hr. day per man, at the fol- owing labor cost per ton:

	Hours	Rate	Total	Rate	Total
abor	3	$.....	$	$5.00	$15.00

Labor Placing Reinforcing Bars.—The labor cost of placing einforcing steel will vary with the average weight of the bars, ne manner in which it is placed; i.e., whether bars may be aid loose or whether it is necessary to tie them in place, and pon the class of labor employed.

In many of the larger cities there are concerns that make a pecialty of setting reinforcing steel. These men become very dept at this work and under favorable conditions can place teel for 25% less than the average iron worker. For this reason osts are given both ways and the estimator should use his own udgment as to the class of workmen obtainable.

In the larger cities the setting of reinforcing steel is usually ublet to a firm or individual specializing in reinforcing steel etting only and the work may often be sublet at $70.00 to $100.00 er ton, including unloading steel on the job, handling and placing eady to receive concrete.

Setting Reinforcing Bars.—On jobs using bars ⅝" and under, here it is not necessary to tie them in place, a man should andle and place 700 to 900 lbs. per 8-hr. day, at the following abor cost per ton:

	Hours	Rate	Total	Rate	Total
ron worker	20.7	$.....	$.....	$7.10	$146.97

Experienced reinforcing steel setters should handle and place 00 to 1,100 lbs. of steel per 8-hr. day, at the following labor ost per ton:

	Hours	Rate	Total	Rate	Total
einforcing steel setter..	16	$.....	$.....	$7.10	$113.60

On jobs using bars ¾" and heavier, where it is not necessary o tie the bars in place, a man should handle and place 900 to ,100 lbs. of steel per 8-hr. day, at the following labor cost per on:

	Hours	Rate	Total	Rate	Total
ron worker	16	$.....	$.....	$7.10	$113.60

An experienced reinforcing steel setter should handle a
place 1,400 to 1,600 lbs. of steel per 8-hr. day, at the followi
labor cost per ton:

	Hours	Rate	Total	Rate	Total
Reinforcing steel setter	10.6	$.....	$.....	$7.10	$75.26

Setting Reinforcing Bars Tied in Place.—On jobs havi
concrete floors where it is necessary to tie the bars in pla
with tie wire, and where lightweight bars, ($\frac{5}{8}$" and under) a
used, a man should handle, place and tie 600 to 800 lbs. per 8-h
day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Iron worker	23	$.....	$.....	$7.10	$163.30

An experienced reinforcing steel setter should handle, pla
and tie 800 to 1,000 lbs. of steel per 8-hr. day, at the followi
labor cost per ton:

	Hours	Rate	Total	Rate	Total
Reinforcing steel setter	17.8	$.....	$.....	$7.10	$126.38

On jobs using heavy bars, ($\frac{3}{4}$" and over) a man should hand
set and tie 800 to 1,000 lbs. of steel per 8-hr. day, at the follo
ing labor cost per ton:

	Hours	Rate	Total	Rate	Total
Labor or iron worker	17.8	$.....	$.....	$7.10	$126.38

An experienced reinforcing steel setter should handle, set a
tie 1,300 to 1,500 lbs. per 8-hr. day, at the following labor c
per ton:

	Hours	Rate	Total	Rate	Total
Reinforcing steel setter	11.5	$.....	$.....	$7.10	$81.6

Welded Steel Fabric or Mesh Reinforcing

Welded steel fabric is a popular and economical reinforci
for concrete work of all kinds, especially driveways and floo
It may also be used for temperature reinforcing, beam a
column wrapping, road and pavement reinforcing, cement g
work, etc.

It is usually furnished in square or rectangular mesh.

It is usually sold at a certain price per sq. ft. or sq. yd. d
pending upon the weight.

Prices of mesh vary with quantity ordered and freight fr
mill to destination. Typical prices for some styles usua
stocked, with truck job site delivery in Chicago follow: Pric
are per 100 sq. ft.

Style	Wt. Per 100 Sq. Ft.	Under 1 Ton	1 to 5 Tons	5 to 20 Tons	20 To and o
6x6- 6x6	42 lbs.	$4.76	$4.47	$4.19	$4.
6x6- 8x8	30 lbs.	3.40	3.19	2.99	2
6x6-10x10	21 lbs.	2.50	2.35	2.21	2.

Labor Placing Steel Fabric on Floors.—When used for r
inforcing floor slabs or for temperature reinforcing, a m

Sizes and Weights of Welded Steel Fabric

Style	Weight per 100 Sq. Ft. Based on Net Width of 60"	Spacing of Wires in Inches		A.S.&W. Co. Steel Wire Gauge Number		Sect. Areas Sq. In. per Ft.	
		Longit.	Trans.	Longit.	Trans.	Longit.	Trans.
22-1616*	13	2	2	16	16	.018	.018
22-1414*	21	2	2	14	14	.030	.030
22-1313	28	2	2	13	13	.039	.039
22-1212*	37	2	2	12	12	.052	.052
22-1111*	48	2	2	11	11	.068	.068
22-1010	60	2	2	10	10	.086	.086
24-1414*	16	2	4	14	14	.030	.015
24-1314*	19	2	4	13	14	.039	.015
24-1212*	28	2	4	12	12	.052	.026
212-38	105	2	12	3	8	.280	.021
212-06	166	2	12	0	6	.443	.029
216-812	46	2	16	8	12	.124	.007
216-711	55	2	16	7	11	.148	.008
216-610	65	2	16	6	10	.174	.011
216-510	75	2	16	5	10	.202	.011
216-49	89	2	16	4	9	.239	.013
216-38	104	2	16	3	8	.280	.015
216-28	119	2	16	2	8	.325	.015
216-17	139	2	16	1	7	.377	.018
33-1414*	14	3	3	14	14	.020	.020
33-1212*	25	3	3	12	12	.035	.035
33-1111*	32	3	3	11	11	.046	.046
33-1010	41	3	3	10	10	.057	.057
33-99	49	3	3	9	9	.069	.069
33-88	58	3	3	8	8	.082	.082
316-812	32	3	16	8	12	.082	.007
316-711	38	3	16	7	11	.098	.009
316-610	45	3	16	6	10	.116	.011
316-510	52	3	16	5	10	.135	.011
316-49	61	3	16	4	9	.159	.013
316-38	72	3	16	3	8	.187	.015
316-28	83	3	16	2	8	.216	.015
316-17	96	3	16	1	7	.252	.018
316-06	113	3	16	0	6	.295	.022
44-1414*	11	4	4	14	14	.015	.015
44-1313*	14	4	4	13	13	.020	.020
44-1212*	19	4	4	12	12	.026	.026
44-1010	31	4	4	10	10	.043	.043
44-88	44	4	4	8	8	.062	.062
44-77	53	4	4	7	7	.074	.074
44-66	62	4	4	6	6	.087	.087
44-44	85	4	4	4	4	.120	.120
48-1313*	11	4	8	13	13	.020	.010
48-1214*	12	4	8	12	14	.026	.008
48-1212*	14	4	8	12	12	.026	.013
48-1112*	17	4	8	11	12	.034	.013
48-1012	20	4	8	10	12	.043	.013
48-912	23	4	8	9	12	.052	.013
48-812	27	4	8	8	12	.062	.013
48-711	33	4	8	7	11	.074	.017

Sizes and Weights of Welded Steel Fabric

Style	Weight per 100 Sq. Ft. Based on Net Width of 60"	Spacing of Wires in Inches		A.S.&W. Co. Steel Wire Gauge Number		Sect. Areas Sq. In. per Ft.	
		Longit.	Trans.	Longit.	Trans.	Longit.	Trans.
412-1212*	13	4	12	12	12	.026	.009
412-1112*	16	4	12	11	12	.034	.009
412-1012	19	4	12	10	12	.043	.009
412-912	22	4	12	9	12	.052	.009
412-812	25	4	12	8	12	.062	.009
412-711	31	4	12	7	11	.074	.011
412-610	36	4	12	6	10	.087	.014
412-510	42	4	12	5	10	.101	.014
412-57	45	4	12	5	7	.101	.025
412-49	49	4	12	4	9	.120	.017
416-1012	18	4	16	10	12	.043	.007
416-912	21	4	16	9	12	.052	.007
416-812	25	4	16	8	12	.062	.007
416-711	30	4	16	7	11	.074	.009
416-610	35	4	16	6	10	.087	.011
416-510	40	4	16	5	10	.101	.011
416-49	48	4	16	4	9	.120	.013
416-38	56	4	16	3	8	.140	.015
416-28	64	4	16	2	8	.162	.015
66-1212*	13	6	6	12	12	.017	.017
66-1010	21	6	6	10	10	.029	.029
66-99	25	6	6	9	9	.035	.035
66-88	30	6	6	8	8	.041	.041
66-77	36	6	6	7	7	.049	.049
66-66	42	6	6	6	6	.058	.058
66-55	49	6	6	5	5	.067	.067
66-46	50	6	6	4	6	.080	.058
66-44	58	6	6	4	4	.080	.080
66-33	68	6	6	3	3	.093	.093
66-22	78	6	6	2	2	.108	.108
66-11	91	6	6	1	1	.126	.126
66-00	107	6	6	0	0	.148	.148
612-77	27	6	12	7	7	.049	.025
612-66	32	6	12	6	6	.058	.029
612-55	37	6	12	5	5	.067	.034
612-44	44	6	12	4	4	.080	.040
612-33	51	6	12	3	3	.093	.047
612-25	52	6	12	2	5	.108	.034
612-22	59	6	12	2	2	.108	.054
612-17	56	6	12	1	7	.126	.025
612-14	61	6	12	1	4	.126	.040
612-11	69	6	12	1	1	.126	.063
612-06	65	6	12	0	6	.148	.029
612-03	72	6	12	0	3	.148	.047
612-00	81	6	12	0	0	.148	.074

should place 1,400 to 1,600 sq. ft. of fabric per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Iron worker	0.53	$.....	$.....	$7.10	$3.76
Cost per sq. ft.					.038

Clay Tile for Tile and Concrete Floors

The labor cost of handling and placing clay tile for combination tile and concrete joist floor construction will vary with the size of the tile, the class of work and the amount of handling necessary.

On straight jobs having long spans without much cutting for pipes and conduits, a mason will lay far more tile per day than on hospitals, schools, hotels, apartments, etc., requiring cutting and fitting for pipes, sleeves and chases through the floor, etc., as it is the cutting and fitting that requires the time.

If the tile are laid before the pipe trades have completed their roughing-in, it is usually necessary to go over the floor a second time and straighten the rows of tile before the concrete can be placed. This also adds to the labor cost.

The following table gives the approximate number of tile a man can wheel per load, using tile barrows for wheeling the tile from stock piles to floor.

Size of Tile in Inches	Wt. Each Tile lbs.	No. Tile per Load
3"x12"x12"	15	16-20
4"x12"x12"	16	14-16
5"x12"x12"	19-22	12-14
6"x12"x12"	22-24	10-12
8"x12"x12"	30	8
10"x12"x12"	36	8
12"x12"x12"	40	6- 8

It is difficult to say just how many loads a man will make per hr. or per day without knowing job conditions, such as length of haul, method of delivery, hoisting, etc.

Labor Costs Handling and Setting 100 Sq. Ft. Clay Floor Tile

Size of Tile in Inches	Straight Work Without Much Cutting or Fitting: Mason Hours	Labor Hours	Hoist Engr.*	No. Tile Placed per 8-Hr. Day	Jobs Requiring Cutting and Fitting: Mason Hours	Labor Hours	Hoist Engr.*	No. Tile Placed per 8-Hr. Day
3"x12"x12"	0.70	3.5	0.4	1,100-1,200	1.15	3.5	0.4	650-750
4"x12"x12"	0.70	3.5	0.4	1,100-1,200	1.15	3.5	0.4	650-750
5"x12"x12"	0.94	4.7	0.5	800- 900	1.33	4.7	0.5	550-650
6"x12"x12"	0.94	4.7	0.5	800- 900	1.33	4.7	0.5	550-650
8"x12"x12"	0.94	4.7	0.5	800- 900	1.33	4.7	0.5	550-650
10"x12"x12"	1.15	5.7	0.6	650- 750	1.45	5.7	0.6	500-600
12"x12"x12"	1.15	5.7	0.6	650- 750	1.45	5.7	0.6	500-600

If necessary to straighten the rows of tile after the pipe trade have installed their work, add ¼-hr. mason time per 100 sq. f

Labor Handling and Placing 100 Sq. Ft. 3″ or 4″ Clay Tile fo Combination Tile and Concrete Floors

Straight Work without much cutting or fitting

	Hours	Rate	Total	Rate	Total
Labor	3.5	$.....	$.....	$5.00	$17.50
Mason	0.7	.....	.....	7.10	4.97
Hoisting engineer*	0.4	.....	.....	6.00	2.40
Cost per 100 sq. ft.	4.6		$.....		$24.87
Cost per sq. ft.			.....		.24

For jobs requiring considerable cutting and fitting, add 0.45 h mason time.

Labor Handling and Placing 100 Sq. Ft. 6″ or 8″ Clay Tile fo Combination Tile and Concrete Floors

Straight Work without much cutting or fitting

	Hours	Rate	Total	Rate	Total
Labor	4.70	$.....	$.....	$5.00	$23.50
Mason	0.94	.....	.....	7.10	6.67
Hoisting engineer*	0.50	.....	.....	6.00	3.00
Cost per 100 sq. ft.	6.14		$.....		$33.17
Cost per sq. ft.			.....		.33

For jobs requiring considerable cutting and fitting, add 0.39-h mason time.

Labor Handling and Placing 100 Sq. Ft. 10″ or 12″ Clay Tile fo Combination Tile and Concrete Floors

Straight Work without much cutting or fitting

	Hours	Rate	Total	Rate	Total
Labor	5.70	$.....	$.....	$5.00	$28.50
Mason	1.15	.....	.....	7.10	8.17
Hoisting engineer*	0.60	.....	.....	6.00	3.60
Cost per 100 sq. ft.	7.45		$.....		$40.27
Cost per sq. ft.			.....		.40

For jobs requiring considerable cutting and fitting, add 0.3-h mason time.

Filling Ends of Clay Tile Fillers with Cement Mortar.—T prevent concrete from running into the ends of each row tile fillers the end voids must be plugged. This is general done before setting tile fillers into place and is usual

*Add only if necessary to hoist tile above the first floor.

accomplished by placing a number of tile on end on planks, sheets of old plywood, etc., and pouring cement mortar into the voids, filling them about ¼ full.

A mason and a helper working together should fill 500 to 550 tile in an 8-hr. day at the following cost per 100 pieces of tile:

	Hours	Rate	Total	Rate	Total
Mason	1.5	$.....	$.....	$7.10	$10.65
Labor	1.5			5.00	7.50
Cost per 100 pieces	3.0		$.....		$18.15
Cost per tile			.....		.182

STEELFORMS FOR JOIST CONSTRUCTED FLOORS AND ROOFS

On jobs using steelforms for concrete joist floor and roof construction, the variations in the labor cost of handling and placing the forms is not as great as with clay tile. This is due to the light weight of the reusable steelforms and the ease in handling them from floor to floor. The depth of the form does not materially affect the labor cost of handling and placing.

Where the same size steelforms are used on a number of floors, they are removed after the concrete has attained the desired strength and reused again on the same job until the work is complete. The removable steelforms are available and can be furnished by companies specializing in this type of work. These companies will erect and remove the steelforms with or without the supporting centering at a stipulated lump sum for the entire job.

Removable steelforms in flange and adjustable type are made from 14, 15 and 16 gauge metal that will stand hard usage. The flange type are nailed through the flanges while the adjustables are nailed through the sides. The flange type steelforms are furnished in 20″ and 30″ widths as standard widths in standard depths of 6″, 8″, 10″, 12″ and 14″. The intermediate forms are in lengths of 1′, 2′ and 3′ with either end caps, 6″ ends or 1′ straight ends as the closures. In addition to the straight ends, there are also single tapered end forms in 3′ lengths for the various depths. Also available are adjustable straight side type forms that can be set to a depth of 8″, 10″, 12″, 14″ and 15″. Likewise, these are furnished in standard 20″ and 30″ widths and have the same combination of 1′, 2′ and 3′ intermediates, end forms and the 3′ single tapered ends. For filling out spaces, filler forms are furnished in 10″ and 15″ widths matching the steelform depths as described. Tapered end forms are not furnished in the filler widths. Removable steelforms made from a lighter gauge metal do not

withstand job abuse, particularly with men working over them before the concrete is placed and as a result, often dent badly so that it requires considerable extra concrete and gives a poor surface finish. In addition, there is added labor expense in reconditioning the forms prior to the next use.

For two-way concrete joist construction, one-piece metal domes are also available. The depths furnished in the 30" x 30" void are 8", 10", 12" and 14", and in the 19" x 19" void are 4", 6", 8", 10" and 12". Flanges for the 30/30 domes are 3" wide to make a 3 ft. module and for the 19/19 domes 2½" wide to make a 2 ft. module. The metal gauge ranges from 14 to 16 gauge.

The steelforms and steeldomes must be nailed to the wood supporting centering to hold them rigid and in line while the concrete is placed.

It is common practice to oil the forms prior to the installation of the reinforcing steel so that they can be removed easier from the ceiling and without concrete adhering to their surfaces.

Estimating Quantities of Steelforms—In estimating the area of floor and roof construction requiring removable or permanent forms, no deductions are to be made for beams or for tees of beams or for wide joists. Openings 50 square feet or over are to be deducted except when the company furnishing the steelforms proposes to furnish the wood centering, in which case only openings 100 square feet or over are to be deducted. Concrete joist construction may be supported by any one of three types of structural systems and in addition to the aforementioned general estimating rules the job area is subject to the following special rules: For a reinforced concrete frame, the areas are to be figured out-to-out of concrete frame; for a structural steel frame, the areas are to be figured center to center spandrel beams; and for bearing wall construction, the areas are to be figured clear inside brick walls plus a bearing on all walls of 6".

Labor Handling and Placing Steelforms—The labor cost of placing steelforms will vary with the type of form, type of building, quantity of equipment furnished, amount of horizontal and vertical movement of equipment, depressions, openings in the slabs, headers, etc., and the locality in which the work is being executed.

Steelforms are placed usually by carpenters and laborers. In a few localities, iron workers handle the steelforms from the point of removal from the concrete ceiling to the next point of steelform installation on the job. In most localities, however, laborers assist the carpenters and handle the steelforms to the next point of erection on the job ready for the carpenter to install the steelform

to the wood centering. The local area practice of work assignment affects greatly the labor costs and should be the basis upon which the estimated costs are determined.

The following costs are based on the steelforms being placed by experienced men such as employed by companies specializing in the erection and removal of steelforms. If inexperienced men are used, increase the costs at least 25 percent.

On straight run work using flange type steelforms such as factory buildings, garages, warehouses, etc. having typical spans without much cutting for headers, openings, etc., an experienced crew consisting of two (2) carpenters and four (4) laborers should handle and place steelforms over approximately 3,500 square feet of floor area in an eight hour day at the following direct labor cost per 100 square feet.

	Hours	Rate	Total	Rate	Total
Mechanic	.46	.....	.....	$6.75	$3.11
Labor	.91	.....	.....	5.00	4.55
Total Direct Labor Cost per 100 sq. ft.	1.37				$7.66
Direct Unit Labor Cost per sq. ft.					0.077

For school buildings, hospitals, apartments, office buildings, etc., where the concrete joist require fitting and adjusting around pipes, pipe sleeves, chases, conduits, the handling and placing costs of the flange type equipment could increase as much as 40-50 percent, depending on the amount of special work required.

Labor Handling and Removing or Stripping Steelforms

In removing or stripping flange type steelforms after the concrete has set, an experienced crew usually consisting of two (2) carpenters and three (3) laborers can remove the steelforms from the ceiling from about 4,000 sq. ft. of floor pr 8-hr. day, at the following direct labor cost per 100 sq. ft.

	Hours	Rate	Total	Rate	Total
Mechanic	.40	.....	.....	$6.75	$2.70
Labor	.60	.....	.....	5.00	3.00
Total Direct Labor Cost per 100 sq. ft.	1.00		.....		$5.70
Direct Unit Labor Cost per sq. ft.					0.057

It should be noted that the above costs are based on flange type steelforms. The cost for handling and placing the one-piece dome

is slightly higher. The cost for handling and placing the adjustable type steelform is about 33⅓ percent higher.

Direct Labor Costs for Handling, Placing and Removing Flange Type Steelforms on 100 Sq. Ft. of Gross Floor Area

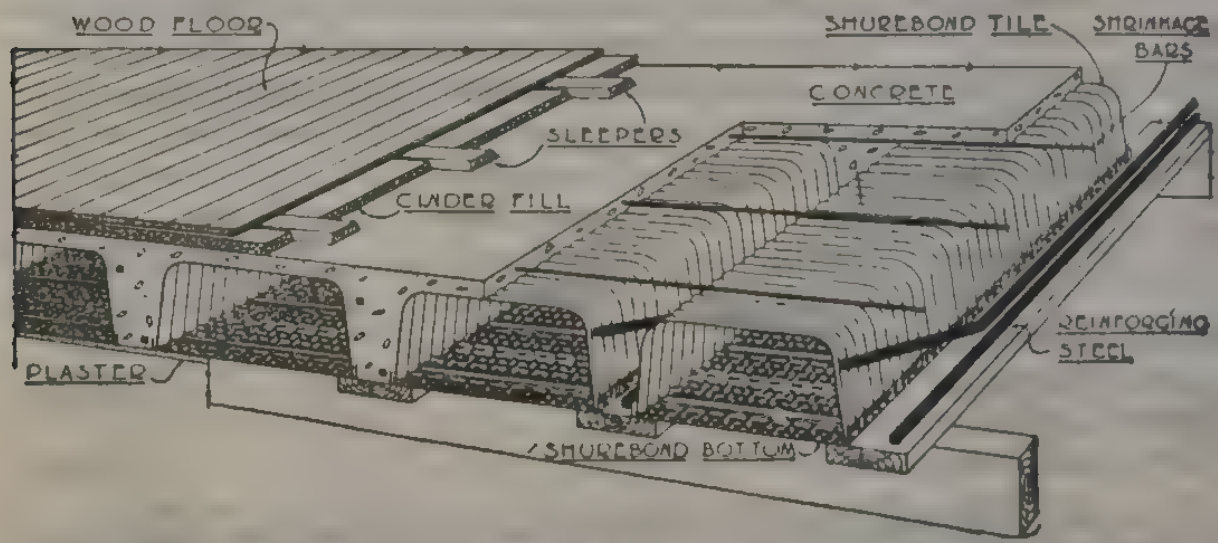
Removable flange type steelforms can be installed and removed on jobs with large productive areas having a minimum amount of headers and openings, depressions, etc. with an average working crew for the following units:

	Hours	Rate	Total	Rate	Total
Labor Handling and Placing Steelforms					
Mechanic	.46	.....	.....	$6.75	$ 3.11
Labor	.91	.....	.....	5.00	4.55
Labor Removing Steelforms					
Mechanic	.40	.....	.....	6.75	2.70
Labor	.60	.....	.....	5.00	3.00
Total Direct Labor Cost per 100 sq. ft.	2.37	.....	.....		$13.36
Direct Unit Labor Cost per sq. ft.					.134

The combined direct labor costs for handling, placing and removing the one-piece metal domes will be the same or slightly higher, while the labor costs for an adjustable type steelform will be approximately 33⅓ percent higher.

The Shurebond Unit System of Concrete Joist Construction*—This system of metal tile and concrete joist construction is similar

*Goldsmith Metal Lath Co., Cincinnati, Ohio.



Shurebond Unit System of Concrete Joist Construction

to other pan systems, except it incorporates a metal lath bottom, which furnishes a plaster base when ceilings are to be plastered. When used in buildings that do not have plastered ceilings, the metal lath bottom may be omitted.

Shurebond permanent metal tile are furnished in regular 20" and 30" widths, but may also be furnished in other widths.

Shurebond metal tile are of sufficient strength to stand the job traffic without planking, such weight increasing as the width of the pan increases.

Where union labor is used, lathers set the lath bottom units, carpenters set the metal tile and end units and laborers unload the trucks, hoist and distribute the tile and lath ready for placing. If union labor is not required, one class of labor may handle the entire job.

The labor handling and placing metal lath and tile for 100 sq. ft. of floor should cost as follows:

	Hours	Rate	Total	Rate	Total
Metal Lather	0.42	$.....	$.....	$6.50	$ 2.73
Carpenter	0.77	.....	.....	6.75	5.20
Labor	0.97	.....	.....	5.00	4.85
Cost per 100 sq. ft.	2.16		$.....		$12.78
Cost per sq. ft.			.....		.128

If metal lath ceilings are not required, omit time of metal lather as given above.

Shurebond removable floor tile are furnished in the standard 20" and 30" widths, with usual 10", 15" and 24" fill-in tile. They can also be furnished with any degree of taper or bevel for end tile to take care of shear.

If Shurebond removable tile are used instead of permanent tile, figure same labor costs as given on previous pages for placing and removing metal pans.

Ceco Steelform Construction.*—Ceco Steelform Construction is a combination of concrete joist construction and thin top slabs. The steelforms are formed of 14, 15, or 16 gauge steel, depending on the width and depth of the form. These forms are placed on supporting wood centering and removed from the concrete after the concrete has reached sufficient strength. The type of forms made available to the industry by The Ceco Corporation are flange forms, the most commonly used type of form, followed by the one-piece metal dome, adjustable forms and the one-piece longforms.

*The Ceco Corporation.

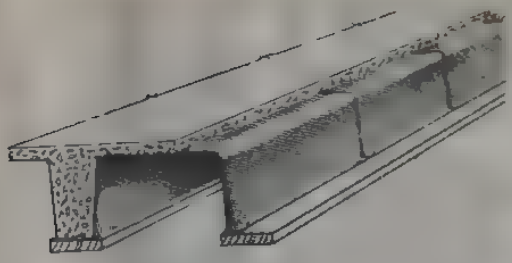
Sizes and Cu. Ft. Displacement of Metal Pan in Shurebond* System of Concrete Joist Construction

Depth of Tile in Inches	Displacement in Cubic Feet Per Lin. Foot						Difference in displacement between std. & st. sided tile cu. ft. lin. ft.	Increment in displacement for 1" change in width of tile cu. ft. lin. ft.
	20" wide at base		24" wide at base		30" wide at base			
	Standard Tile	Straight Sided Tile	Standard Tile	Straight Sided Tile	Standard Tile	Straight Sided Tile		
4	0.523	0.537	0.634	0.648	0.801	0.815	0.014	0.0278
5	0.655	0.676	0.794	0.815	1.002	1.023	0.021	0.0347
6	0.788	0.815	0.955	0.982	1.205	1.232	0.027	0.0417
7	0.921	0.954	1.115	1.148	1.407	1.440	0.033	0.0486
8	1.055	1.093	1.277	1.315	1.610	1.648	0.038	0.0556
9	1.188	1.232	1.438	1.482	1.813	1.857	0.044	0.0625
10	1.321	1.370	1.599	1.648	2.016	2.065	0.049	0.0694
11	1.455	1.509	1.761	1.815	2.219	2.273	0.054	0.0764
12	1.588	1.648	1.921	1.981	2.421	2.481	0.060	0.0833
13	1.721	1.787	2.082	2.148	2.624	2.690	0.066	0.0903
14	1.855	1.926	2.244	2.315	2.827	2.898	0.071	0.0972
15	1.989	2.065	2.405	2.481	3.030	3.106	0.076	0.1042
16	2.122	2.204	2.566	2.648	3.233	3.315	0.082	0.1111
17	2.256	2.343	2.728	2.815	3.436	3.523	0.087	0.1181
18	2.389	2.481	2.889	2.981	3.639	3.731	0.092	0.1250
19	2.523	2.620	3.051	3.148	3.842	3.939	0.097	0.1319
20	2.656	2.759	3.212	3.315	4.045	4.148	0.103	0.1389
21			3.374	3.481	4.249	4.356	0.107	0.1458
22			3.535	3.648	4.452	4.565	0.113	0.1528
23			3.696	3.815	4.654	4.773	0.119	0.1597
24			3.858	3.981	4.858	4.981	0.123	0.1667
25					5.061	5.190	0.129	0.1736
26					5.264	5.398	0.134	0.1806
27					5.467	5.606	0.139	0.1875
28					5.670	5 815	0.145	0.1944
29					5.873	6.023	0.150	0.2014
30					6.076	6.231	0.155	0.2083

The cost of the steelforms installed in a building will depend on a number of factors such as the type of steelform used, the size of the job, the number of reuses of the equipment, location, availability of the steelforms with respect to warehouse stocks, etc. Local working conditions also play a very important part in job costs.

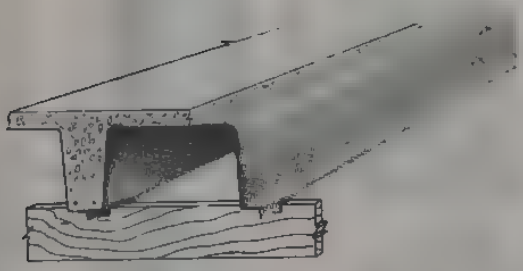
The Ceco steelform service includes supplying the necessary steelforms and the labor for their erection and removal. Also offered in a complete service of furnishing and erecting all open centering for the support of the steelforms. In steeldome construction centering is usually included for the concrete solid slab areas that are of the same depth as the dome construction and within the floor areas containing the steeldomes. The quotations and contracts are generally on a lump sum basis for specific projects. It is always recommended that the steelform prices be

*Goldsmith Metal Lath Co., Cincinnati, Ohio.

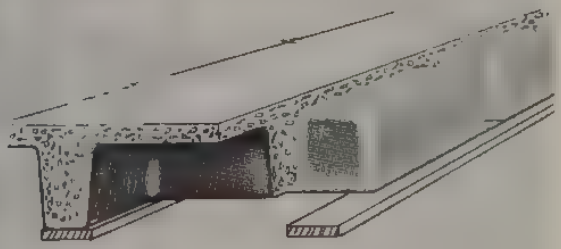


flange type

adjustable type



longform type



steeldome type

obtained from a steelform supplier before finalizing and submitting a bid on this portion of the job costs.

The Code of Standard Practice for concrete joist construction floor forms presented by the Concrete Reinforcing Steel Institute will govern estimating areas in all relations between the metal form company and the buyer. A floor is to be considered a slab of concrete joist construction, whether it be a floor or roof slab and any intermediate or miscellaneous levels of concrete joist construction shall not be considered as additional floors unless the areas of such slabs are at least 30 percent of the area of a typical or average floor and not less than 1,000 sq. ft.

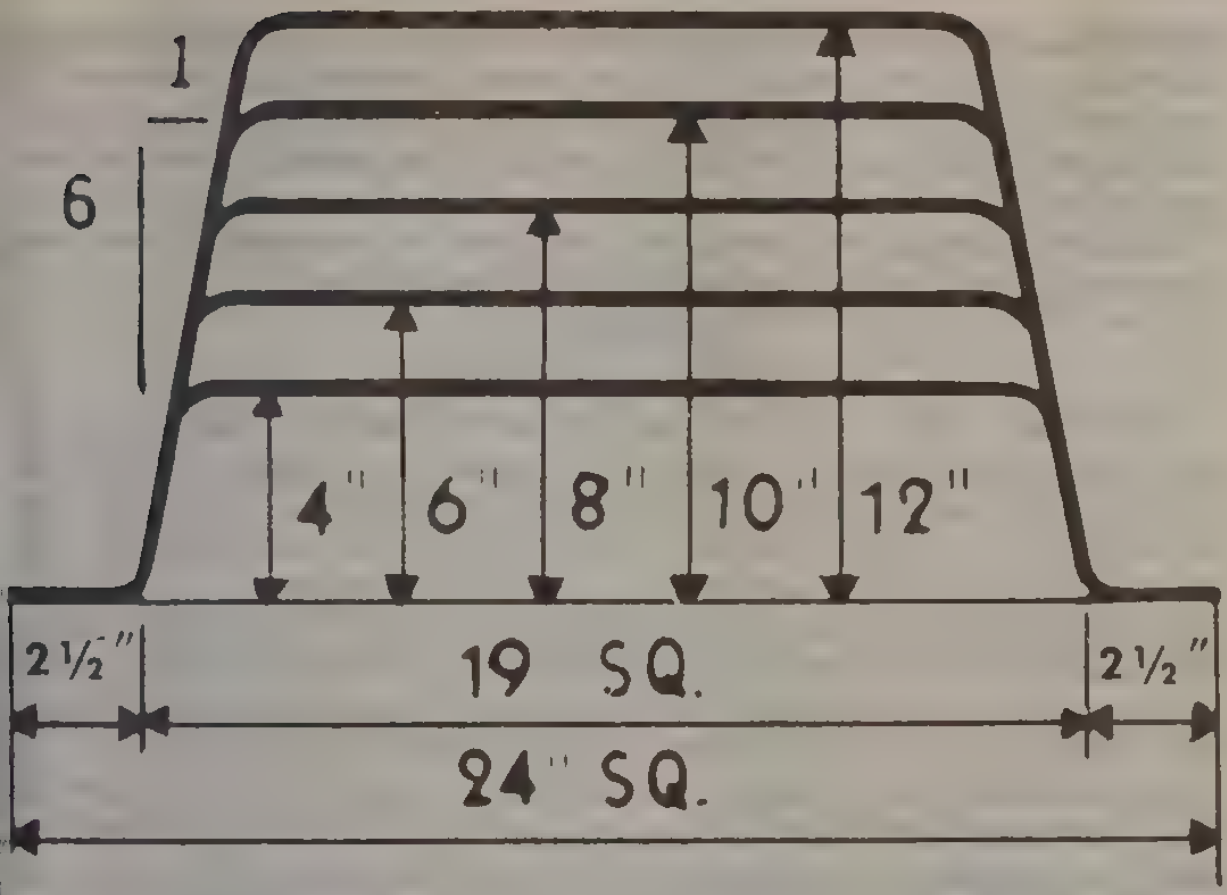
The Grid System of Flat Slab Construction*.—This system of flat slab construction for floors and roofs is made up of removable steel domes which leave hollow squares on the under side of the ceiling, as shown in the accompanying illustration.

The steel domes require support in only one direction during construction and the forms can be built in the same manner as for other pan constructed floors. In the majority of designs the bottoms of the plinths are flush with the bottom of the ribs, thus doing away with the expense of forming drop panels.

The 2 foot removable one piece steel domes are formed from 16-ga. steel. These domes are furnished in depths of 12", 10", 8", 6" and 4" and are 2'-0" square out-to-out of flanges. The 2½" flange on four sides butt to form 5" ribs. The coffers formed are 1'-7" at

*Grid Flat Slab Corporation, Boston, Mass. 02122.

Method of Constructing Open Wood Centering and Placing Steelforms for Concrete Joist Floor Construction.



Sizes and Shapes of Domes Used in the Grid System of Flat Slab Construction.

the base and slope upwards on each side with a bevel of 1" in 6". All domes are formed with the same slope and are readily interchangeable to provide depressed slab areas or underfloor duct installation areas. They are so rigid that runways for concrete placing equipment may be placed directly upon them.

The 12", 10", 8", 6" and 4" domes displace 2 cu. ft., 1.75 cu. ft., 1.5 cu. ft., 1.125 cu. ft. and .8 cu. ft. respectively. An easy method of estimating the concrete is to figure the slab as though it were solid concrete and then deduct the displacement for each dome.

The 3 foot removable one piece steel domes are formed of 14 ga. steel. They are furnished in depths of 14", 12" and 10", and are 3 feet square out-to-out of flanges. The 3" flanges on all four sides butt to form 6" ribs. The coffers formed are 2'-6" at the base and slope upward on each side with a bevel of 1" in 8". The 14", 12" and 10" domes displace 6.4, 5.45 and 4.5 cu.ft. of concrete respectively.

The Grid domes are furnished on a lease basis and the Grid Flat Slab Corporation does furnish an experienced working foreman who will be placed on the contractor's payroll at the prevailing wage to supervise the oiling, placing and removing of

Grid domes. Approximate price per square foot of gross floor or roof area for jobs containing less than 50,000 sq. ft. is 18 to 19 cts. per sq. ft.; 50,000 to 100,000 sq. ft. of floor area, 15 to 16 cts. per sq. ft., and over 100,000 sq. ft. of floor area, 13 to 14 cts. per sq. ft.

When figuring jobs using this system, it is essential to communicate direct with the company* for quotations.

CONCRETE

Lightweight Concrete

There are two types of lightweight concrete. One type, in use for a considerable time, is produced by simply combining portland cement and a lightweight aggregate. The second is known as aerated concrete. The process is patented and the cost is little, if any, higher than ordinary concrete.

Aerated concrete is produced by a process depending upon the introduction of certain chemicals to generate gases which cause the mass to expand. The weight of aerated concrete may be controlled with a variation of from 20 lbs. per cu. ft. to approximately the weight of ordinary lightweight concrete. For average conditions a weight of 40 to 50 lbs. per cu. ft. with a compressive strength of about 500 lbs. per sq. in. is usually selected.

Aerated concrete is fireproof, has a low moisture absorption rate and provides good insulation against the transmission of heat and sound. It may be sawed or nailed as readily as other lightweight concrete.

All lightweight concretes are of decided advantage for partition walls and fireproofing, whether in monolithic or precast unit form; for floor fill and for roof slabs. The estimator should consider the combined advantages of each type of lightweight concrete before selection.

Haydite Concrete.—Haydite concrete uses burnt clay or shale for coarse aggregate instead of gravel or crushed stone. This inert, cellular material weighs less than 50 lbs. per cu. ft. and when mixed with ordinary torpedo sand and portland cement, produces concrete weighing about 98 lbs. per cu. ft. instead of 150 lbs. for ordinary concrete.

Full structural strengths can be obtained with Haydite concrete and in many instances a redesign based on lightweight concrete and reduced dead load more than pays for the slight additional cost of the aggregates.

The cost of Haydite coarse aggregate will vary with the locality, freight, etc., but under ordinary conditions does not

*Grid Flat Slab Corporation, Boston, Mass. 02122.

exceed 20 to 25 cts. per cu. ft. more than for ordinary concrete.

Perlite Lightweight Concrete.—For lightweight concrete using Perlite as the aggregate, refer to "Concrete Floors and Walks."

Pottsco Lightweight Aggregate.—Pottsco lightweight aggregate is an expanded blast furnace slag. By special processes, molten slag is converted into hard, cellular clinker, which is crushed and screened to commercial sizes, ready for use with portland cement and water, without the addition of sand or other materials. It is supposed to be chemically inert and has no corrosive effect on structural or reinforcing steel, plaster or paint.

It is furnished in two sizes, ¼" to ½" which weighs 1200 to 1300 lbs. per cu. yd. and ¼" to dust, weighing 1400 to 1500 lbs. per cu. yd.

Pumice Lightweight Concrete.—For lightweight concrete using Pumice as the aggregate, refer to "Concrete Floors and Walks."

Vermiculite Lightweight Concrete.—Refer to "Vermiculite Concrete" section.

Waylite Lightweight Concrete.—For lightweight concrete us-

Forming Reinforced Concrete Floors Using Adjustable Shores.

ing Waylite as the aggregate, refer to "Concrete Floors and Walks."

Reinforced Concrete

After the forms, tile and reinforcing steel are in place, the job is ready for concrete. This should include the cost of gravel or crushed stone, sand and cement used in the concrete mixture as well as the labor cost of handling materials, mixing, hoisting, placing and curing the concrete.

For many years concrete used in reinforced concrete construction was specified to be mixed in the proportions of 1:1:2, 1:1½:3, 1:2:4, etc., depending upon the class of work for which it was used. More modern practice specifies that concrete used for specific purposes shall develop a compressive strength of 2,500, 3,000, 3,750 or 4,000 lbs. or more per sq. in. at 28 days, and is based upon the amount of mixing water (including moisture in aggregates) used per sack of cement. This method of proportioning concrete mixtures is fully described on pages 280 to 296.

On nearly all classes of reinforced concrete building work, such as columns, beams, girders, floor slabs, etc., the coarse aggregate is graded from ¼" to 1" in size. Where conditions permit, however, coarse aggregate graded from ¼" to 1½" is used as it is absolutely necessary to cover and surround all reinforcing steel to produce a smooth surface on all exposed concrete.

When used on any of the combination tile and concrete joist systems, the coarse aggregate should not exceed ¾" in size or it will not fill the voids in the narrow joists and surround the reinforcing bars as it should.

Estimating the Quantities of Cement, Sand, Gravel or Crushed Stone Required for One Cu. Yd. of Concrete

A full description of methods and tables giving the amounts of cement, sand, gravel and crushed stone required for one cubic yard of concrete, mixed in any proportion, are given on pages 280 to 296.

Estimating the Quantity of Concrete Required for Various Types of Concrete Floors

If all concrete floors were merely solid slabs of concrete it would be an easy matter to compute the quantity of concrete required per sq. ft. of floor but with so many combination floors consisting of clay tile and metal pans, etc., having joists 4" to 7" wide, 4" to 15" deep and from 16" to 35" on centers it requires considerable figuring to obtain accurate concrete quantities.

Cu. Ft. of Concrete Required for One Sq. Ft. of Solid Concrete Floor

Thickness of Floor in Inches	Cu. Ft. Concrete Per Sq. Ft. Floor	Thickness of Floor in Inches	Cu. Ft. Concrete per Sq. Ft. Floor
2	0.167	7	0.583
2½	0.208	7½	0.625
3	0.25	8	0.667
3½	0.292	8½	0.708
4	0.333	9	0.75
4½	0.375	9½	0.792
5	0.417	10	0.833
5½	0.458	10½	0.875
6	0.50	11	0.917
6½	0.542	11½	0.94
		12	1.00

It is practically impossible to estimate accurately the amount of concrete required per sq. ft. of floor for the various combination tile and joist floors, as they invariably have T beam construction at all beams and girders, solid concrete slabs usually extend in 6″ to 1′-6″ from the outside walls, the joists vary in width and are often doubled under partitions, around stair wells, elevator shafts, etc. The only accurate method is to figure the floors as though they were solid concrete and then deduct for the displacement of the tile or pans.

The tables on the following pages give the volume of concrete displaced by tile and pans of different sizes together with the correct method of using them.

Estimating Quantity of Concrete Required for Combination Clay Tile and Concrete Joist Floors

When figuring concrete quantities for this type of floor construction, figure the entire floor area of the thickness shown as if it were solid concrete. Then make deductions for the displacement of the tile. Example: A floor slab 20′-0″x60′-0″x0′-3″ contains 800 cu. ft. of concrete. Using 6″x12″x12″ tile spaced 16″ on centers and allowing for wall bearing of slab and T beams, each row of tile is 18′-0″ long. With joists 16″ on centers there are 45 rows of tile 18′-0″ long in the slab, 45x18=810 sq. ft. or 405 cu. ft. of concrete displaced by tile, 800-405=395 cu. ft. of concrete in the slab.

The following table gives the number of cu. ft. of concrete displaced by 1 sq. ft. of clay tile of different thicknesses, together with the number of cu. ft. in rows of various lengths

for each size tile. This is the most accurate method to use.

Quantity of Concrete Required for Steelform and Concrete Joist Floor Construction.—Floors of this type should be estimated in the same manner as tile and concrete joist construction, i.e., obtain the entire slab volume as though of solid concrete and deduct for the displacement of the steelforms.

Cu. Ft. of Concrete Displaced by Clay Tile in Clay Tile and Concrete Joist Floor Construction

Size of Tile in Inches	Length of Each Row of Tile in Feet									
	1′	2′	3′	4′	5′	6′	7′	8′	9′	10′
3″x12″x12″	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
4″x12″x12″	0.33	0.67	1.00	1.33	1.66	2.00	2.33	2.66	3.00	3.33
5″x12″x12″	0.42	0.83	1.25	1.67	2.08	2.50	2.92	3.33	3.75	4.17
6″x12″x12″	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
8″x12″x12″	0.67	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67
10″x12″x12″	0.83	1.67	2.50	3.33	4.16	5.00	5.83	6.66	7.50	8.33
12″x12″x12″	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
	11′	12′	13′	14′	15′	16′	17′	18′	19′	20′
3″x12″x12″	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
4″x12″x12″	3.66	4.00	4.33	4.66	5.00	5.33	5.66	6.00	6.33	6.66
5″x12″x12″	4.59	5.00	5.42	5.84	6.25	6.67	7.09	7.50	7.92	8.34
6″x12″x12″	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
8″x12″x12″	7.34	8.00	8.67	9.34	10.00	10.67	11.34	12.00	12.67	13.34
10″x12″x12″	9.16	10.00	10.83	11.66	12.50	13.33	14.16	15.00	15.83	16.66
12″x12″x12″	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00

The deductions for steelform area in floors of this type is not quite as simple as for clay tile, as steelforms are furnished in a number of different sizes, with tapering sides and ends.

Steelforms furnished by different manufacturers vary slightly in shape but not sufficient to materially affect the concrete quantities. Ceco* steelforms have been used in the tables as being typical for general use.

Sizes and Cu. Ft. Displacement of Flange Type Steelforms

Ceco* flange type steelforms slope 1″ in each 12″ in height. Example: a 12″ pan is 20″ wide at the bottom and 18″ wide at the top, because of the 1″ slope on each side. See illustrations on previous pages.

The sides of single tapered endforms slope 1″ for each 12″ in height and one end slopes ¼″ for each 1″ in height. For estimating purposes their displacement is the same as for standard steelforms given above.

*The Ceco Corporation.

Sizes and Cu. Ft. Displacement of Tapered End Forms						Difference Between Tapered end forms and 3'-0" length of straight forms in Cu. Ft.
Depth of Steel-form in Inches	Width at Wide End	Width at Narrow End	Average Width	Length in Feet	Cubic Foot Displace-ment per 3-Ft. Section	
6"	20"	16"	18 "	3'-0"	2.192	0.244
8"	20"	16"	18 "	3'-0"	2.900	0.322
10"	20"	16"	18 "	3'-0"	3.594	0.399
12"	20"	16"	18 "	3'-0"	4.274	0.475
14"	20"	16"	18 "	3'-0"	4.944	0.549
16"	20"	16"	18 "	3'-0"	5.553	0.666
6"	30"	25"	27½"	3'-0"	3.381	0.306
8"	30"	25"	27½"	3'-0"	4.481	0.406
10"	30"	25"	27½"	3'-0"	5.571	0.504
12"	30"	25"	27½"	3'-0"	6.649	0.602
14"	30"	25"	27½"	3'-0"	7.711	0.698
16"	30"	25"	27½"	3'-0"	8.706	1.188

Sizes and Cu. Ft. Displacement of Ceco* Flange Type Steelforms

Depth of Steelform in Inches	Width at Bottom	Width at Top	Average Width	Cubic Foot Displacement per Lin. Ft.
6"	10"	9"	9½"	0.396
8"	10"	8⅔"	9⅓"	0.518
10"	10"	8⅓"	9⅙"	0.636
12"	10"	8"	9"	0.750
14"	10"	7⅔"	8⅚"	0.859
16"	10"	7⅓"	8⅔"	0.964
6"	15"	14"	14½"	0.604
8"	15"	13⅔"	14⅓"	0.796
10"	15"	13⅓"	14⅙"	0.984
12"	15"	13"	14"	1.167
14"	15"	12⅔"	13⅚"	1.345
16"	15"	12⅓"	13⅔"	1.482
6"	20"	19"	19½"	0.812
8"	20"	18⅔"	19⅓"	1.074
10"	20"	18⅓"	19⅙"	1.331
12"	20"	18"	19"	1.583
14"	20"	17⅔"	18⅚"	1.831
16"	20"	17⅓"	18⅔"	2.073
6"	30"	29"	29½"	1.229
8"	30"	28⅔"	29⅓"	1.629
10"	30"	28⅓"	29⅙"	2.025
12"	30"	28"	29"	2.417
14"	30"	27⅔"	28⅚"	2.803
16"	30"	27⅓"	28⅔"	3.298

*The Ceco Corporation.

Sizes and Cu. Ft. Displacement of Adjustable Steelforms

Depth of Steelform in Inches	Width at Bottom	Width at Top	Cubic Foot Displacement per Lin. Ft.
8″	10″	8″	0.514
10″	10″	8″	0.653
12″	10″	8″	0 792
14″	10″	8″	0.931
15″	10″	8″	1.000
8″	15″	13″	0.792
10″	15″	13″	1.000
12″	15″	13″	1.208
14″	15″	13″	1.417
15″	15″	13″	1.521
8″	20″	18″	1.069
10″	20″	18″	1.347
12″	20″	18″	1.625
14″	20″	18″	1.903
15″	20″	18″	2.042
8″	30″	28″	1.625
10″	30″	28″	2.042
12″	30″	28″	2.458
14″	30″	28″	2.875
15″	30″	28″	3.083

Cu. Ft. of Concrete Displaced by Adjustable Steelforms and Tapered Endforms

Depth of Steelform	Width of Steelform	Length of Each Row of Steelforms in Feet									
		10′	11′	12′	13′	14′	15′	16′	17′	18′	19′
8″	30″	15.33	16.96	18.58	20.21	21.83	23.46	25.08	26.71	28.33	29.9
10″	30″	19.33	21.38	23.42	25.46	27.50	29.54	31.59	33.63	35.67	37.7
12″	30″	23.33	25.79	28.25	30.71	33.16	35.62	38.08	40.54	43.00	45.4
14″	30″	27.33	30.21	33.08	35.96	38.83	41.71	44.58	47.46	50.33	53.2
15″	30″	29.33	32.42	35.50	38.58	41.66	44.75	47.83	50.91	54.00	57.0
		20′	21′	22′	23′	24′	25′	26′	27′	28′	29′
8″	30″	31.58	33.21	34.83	36.46	38.08	39.71	41.33	42.96	44.58	46.2
10″	30″	39.75	41.80	43.84	45.88	47.92	49.96	52.01	54.05	56.09	58.1
12″	30″	47.91	50.37	52.83	55.29	57.74	60.20	62.66	65.12	67.58	70.0
14″	30″	56.08	58.96	61.83	64.71	67.58	70.46	73.33	76.21	79.08	81.9
15″	30″	60.16	63.25	66.33	69.41	72.49	75.58	78.66	81.74	84.83	87.9

Cu. Ft. of Concrete Displaced by Flange Type Steelforms and Straight Endforms

Depth of Steelform	Width of Steelform	Length of Each Row of Steelforms in Feet									
		1′	2′	3′	4′	5′	6′	7′	8′	9′	10′
6″	10″	0.40	0.79	1.19	1.58	1.98	2.38	2 77	3.17	3.56	3.96
8″	10″	0.52	1.04	1.55	2.07	2.59	3.11	3.63	4.14	4.66	5.18
10″	10″	0.64	1.27	1.91	2.54	3.18	3.82	4.45	5.09	5.72	6.36
12″	10″	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50
14″	10″	0.86	1.72	2.58	3.44	4.30	5.15	6.01	6.87	7.73	8.59
16″	10″	0.96	1.92	2.88	3.84	4.80	5.75	6.71	7.67	8.63	9.59
		11′	12′	13′	14′	15′	16′	17′	18′	19′	20′
6″	10″	4.36	4.75	5.15	5.54	5.94	6.34	6.73	7.13	7.52	7.92
8″	10″	5.70	6.22	6.73	7.25	7.77	8.29	8.81	9.32	9.84	10.36
10″	10″	7.00	7.63	8.27	8.90	9 54	10.18	10.81	11.45	12.08	12 72
12″	10″	8 25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00
14″	10″	9.45	10.31	11.17	12.03	12.89	13.74	14.60	15.46	16.32	17.18
16″	10″	10.55	11.51	12.47	13.43	14.39	15.34	16.30	17.26	18.22	19.18

Depth of Steelform	Width of Steelform	Length of Each Row of Steelforms in Feet									
		1′	2′	3′	4′	5′	6′	7′	8′	9′	10′
6″	15″	0.60	1.21	1.81	2.42	3.02	3.62	4.23	4.83	5.44	6.04
8″	15″	0.80	1.59	2.39	3.18	3.98	4.78	5.57	6.37	7.16	7.96
10″	15″	0.98	1.97	2.95	3.94	4.92	5.90	6.89	7.87	8.86	9.84
12″	15″	1.17	2.33	3.50	4.67	5.84	7.00	8.17	9.34	10.50	11.67
14″	15″	1.35	2.69	4.04	5.38	6.73	8.07	9.42	10.76	12.11	13.45
16″	15″	1.48	2.96	4.44	5.92	7.40	8.88	10.36	11.84	13.32	14.80
		11′	12′	13′	14′	15′	16′	17′	18′	19′	20′
6″	15″	6.64	7.25	7.85	8.46	9.06	9.66	10.27	10.87	11.48	12.08
8″	15″	8.76	9.55	10.35	11.14	11.94	12.74	13.53	14.33	15.12	15.92
10″	15″	10.82	11.81	12.79	13.78	14.76	15.74	16.73	17.71	18.70	19.68
12″	15″	12.84	14.00	15.17	16.34	17.51	18.67	19.84	21.01	22.17	23.34
14″	15″	14.80	16.14	17.49	18.83	20.18	21.52	22.87	24.21	25.56	26.90
16″	15″	16.28	17.76	19.24	20.72	22.20	23.68	25.16	26.64	28.12	29.60

Depth of Steelform	Width of Steelform	Length of Each Row of Steelforms in Feet									
		1′	2′	3′	4′	5′	6′	7′	8′	9′	10′
6″	20″	0.81	1.62	2.44	3.25	4.06	4.87	5.68	6.50	7.31	8.12
8″	20″	1.07	2.15	3.22	4.30	5.37	6.44	7.52	8.59	9.67	10.74
10″	20″	1.33	2.66	3.99	5.32	6.66	7.99	9.32	10.65	11.98	13.31
12″	20″	1.58	3.17	4.75	6.33	7.92	9.50	11.08	12.66	14.25	15.83
14″	20″	1.83	3.66	5.49	7.32	9.16	10.99	12.82	14.65	16.48	18.31
16″	20″	2.07	4.14	6.21	8.28	10.35	12.42	14.49	16.56	18.64	20.70
		11′	12′	13′	14′	15′	16′	17′	18′	19′	20′
6″	20″	8.93	9.74	10.56	11.37	12.18	12.99	13.80	14.62	15.43	16.24
8″	20″	11.81	12.89	13.96	15.04	16.11	17.18	18.26	19.33	20.41	21.48
10″	20″	14.64	15.97	17.30	18.63	19.97	21.30	22.63	23.96	25.29	26.62
12″	20″	17.41	19.00	20.58	22.16	23.75	25.33	26.91	28.49	30.08	31.66
14″	20″	20.14	21.97	23.80	25.63	27.47	29.30	31.13	32.96	34.79	36.62
16″	20″	22.77	24.84	26.91	28.98	31.05	33.12	35.19	37.26	39.33	41.40

Depth of Steelform	Width of Steelform	Length of Each Row of Steelforms in Feet									
		1′	2′	3′	4′	5′	6′	7′	8′	9′	10′
6″	30″	1.23	2.46	3.69	4.92	6.15	7.37	8.60	9.83	11.06	12.29
8″	30″	1.63	3.26	4.89	6.52	8.15	9.77	11.40	13.03	14.66	16.29
10″	30″	2.03	4.05	6.08	8.10	10.13	12.15	14.18	16.20	18.23	20.25
12″	30″	2.42	4.83	7.25	9.67	12.09	14.50	16.92	19.34	21.75	24.17
14″	30″	2.80	5.61	8.41	11.21	14.02	16.82	19.62	22.42	25.23	28.03
16″	30″	3.30	6.60	9.90	13.20	16.50	19.80	23.10	26.40	29.70	33.00
		11′	12′	13′	14′	15′	16′	17′	18′	19′	20′
6″	30″	13.52	14.75	15.98	17.21	18.44	19.66	20.89	22.12	23.35	24.58
8″	30″	17.92	19.55	21.18	22.81	24.44	26.06	27.69	29.32	30 95	32.58
10″	30″	22.28	24.30	26.33	28.35	30.38	32.40	34 43	36.45	38.48	40.50
12″	30″	26.59	29.00	31.42	33.84	36.26	38.67	41.09	43.51	45.92	48 34
14″	30″	30.83	33.64	36.44	39.24	42.05	44.85	47.65	50.45	53.26	56.06
16″	30″	36.30	39.60	42.90	46.20	49.50	52.80	56.10	59.40	62.70	66.00

Cu. Ft. of Concrete Displaced by Adjustable Steelforms and Straight Endforms

Depth of Steelform	Width of Steelform	Length of Each Row of Steelforms in Feet									
		1′	2′	3′	4′	5′	6′	7′	8′	9′	10′
8″	10″	0.51	1.03	1.54	2.06	2.57	3.08	3.60	4.11	4 63	5.14
10″	10″	0.65	1.31	1.96	2.61	3.27	3.92	4.57	5.22	5 88	6.53
12″	10″	0.79	1.58	2.38	3.17	3.96	4.75	5.54	6.34	7.13	7.92
14″	10″	0.93	1.86	2.79	3.72	4.66	5.59	6.52	7.45	8.38	9.31
15″	10″	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
		11′	12′	13′	14′	15′	16′	17′	18′	19′	20′
8″	10″	5.65	6.17	6.68	7.20	7.71	8.22	8.74	9.25	9.77	10.28
10″	10″	7.18	7.84	8.49	9.14	9.80	10.45	11.10	11.75	12.41	13.06
12″	10″	8.71	9.50	10.30	11.09	11.88	12.67	13.46	14.26	15.05	15.84
14″	10″	10.24	11.17	12.10	13.03	13.97	14.90	15.83	16.76	17.69	18.62
15″	10″	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00

Depth of Steelform	Width of Steelform	Length of Each Row of Steelforms in Feet									
		1′	2′	3′	4′	5′	6′	7′	8′	9′	10′
8″	15″	0.79	1.58	2.38	3.17	3.96	4.75	5.54	6.34	7.13	7.92
10″	15″	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
12″	15″	1.21	2.42	3.62	4.83	6.04	7.25	8.46	9.66	10.87	12.08
14″	15″	1.42	2.83	4.25	5.67	7.09	8.50	9.92	11.34	12.75	14.17
15″	15″	1.52	3.04	4.56	6.08	7.61	9.13	10.65	12.17	13.69	15.21
		11′	12′	13′	14′	15′	16′	17′	18′	19′	20′
8″	15″	8.71	9.50	10.30	11.09	11.88	12.67	13.46	14.26	15.05	15.84
10″	15″	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00
12″	15″	13.29	14.50	15.70	16.91	18.12	19.33	20.54	21.74	22.95	24.16
14″	15″	15.59	17.00	18.42	19.84	21.26	22.67	24.09	25.51	26.92	28.34
15″	15″	16.73	18.25	19.77	21.29	22.82	24.34	25.86	27.38	28.90	30.42

Depth of Steelform	Width of Steelform	Length of Each Row of Steelforms in Feet									
		1	2	3′	4′	5′	6′	7′	8′	9′	10′
8″	20″	1 07	2.14	3.21	4.28	5.35	6.41	7.48	8.55	9.62	10.69
10″	20″	1.35	2.69	4 04	5.39	6.74	8.08	9.43	10.78	12.12	13.47
12″	20″	1.63	3.25	4.88	6.50	8.13	9.75	11.38	13.00	14.63	16.25
14″	20″	1.90	3.81	5.71	7.61	9.52	11.42	13.32	15.22	17.13	19.03
15″	20″	2.04	4.08	6.13	8.17	10.21	12.25	14.29	16.34	18.38	20.42
		11′	12′	13′	14′	15′	16′	17′	18′	19′	20′
8″	20″	11.76	12.83	13.90	14.97	16.04	17.10	18.17	19.24	20.31	21.38
10″	20″	14.82	16.16	17.51	18.86	20.21	21.55	22.90	24.25	25.59	26.94
12″	20″	17.88	19.50	21.13	22.75	24.38	26.00	27.63	29.25	30.88	32.50
14″	20″	20.93	22.84	24.74	26.64	28.55	30.45	32.35	34.25	36.16	38.06
15″	20″	22.46	24 50	26.55	28.59	30.63	32.67	34.71	36.76	38.80	40 84

		10′	11′	12′	13′	14′	15′	16′	17′	18′	19′
8″	30″	16.25	17.88	19.50	21.13	22.75	24.38	26.00	27.63	29.25	30.88
10″	30″	20.42	22.46	24.50	26.55	28.59	30.63	32.67	34.71	36.76	38.80
12″	30″	24.58	27.04	29.50	31.95	34.41	36.87	39.33	41 79	44.24	46.70
14″	30″	28.75	31.63	34.50	37.38	40.25	43.13	46.00	48.88	51.75	54.63
15″	30″	30.83	33.91	37.00	40.08	43.16	46.25	49.33	52.41	55.49	58.58
		20′	21′	22′	23′	24′	25′	26′	27′	28′	29′
8″	30″	32.50	34.13	35.75	37.38	39.00	40.63	42.25	43.88	45.50	47.13
10″	30″	40.84	42.88	44.92	46.97	49.01	51.05	53.09	55.13	57.18	59.22
12″	30″	49.16	51.62	54.08	56.53	58.99	61.45	63.91	66.37	68.82	71.28
14″	30″	57.50	60.38	63.25	66.13	69.00	71.88	74.75	77.63	80.50	83.38
15″	30″	61.66	64.74	67.83	70.91	73.99	77.08	80.16	83.24	86.32	89.41

Sizes and Cu. Ft. Displacement of Ceco* Flange Type Single Tapered Endforms

Endforms are 20" wide at one end tapering to 16" at the other end. 30" Endforms are 30" wide at one end tapering to 25" wide at other end.

Sizes and Cu. Ft. Displacement of Ceco* Adjustable Tapered Steel Endforms

Tapered endforms 3'-0" long are furnished for 30" wide steelforms only. Straight endforms 3'-0" long are furnished for the 30" standard widths and the 20", 15" and 10" special widths.

Depth of Steelform Inches	Width at Wide End	Width at Narrow End	Length in Feet	Cubic Foot Displacement per 3-Ft. Section
8"	30"	25"	3'-0"	4.317
10"	30"	25"	3'-0"	5.483
12"	30"	25"	3'-0"	6.629
14"	30"	25"	3'-0"	7.775
15"	30"	25"	3'-0"	8.347

Another Method of Estimating the Concrete Required for Ceco Steelform* Construction.—The following method of estimating the concrete requirements for Ceco steelform construction is that recommended by the manufacturers.

Figure the concrete as though it were a solid slab and then deduct for displacement of a certain number of lineal feet of straight metal steelforms and tapered endforms.

Ceco steelform construction is a combination of concrete joists and thin slabs. In computing the amount of concrete in the floor construction of a building designed for Ceco Steelforms it is more convenient, and there is less chance for error, to multiply the floor area by the equivalent thickness of the floor construction than to separately figure the concrete in the joists by multiplying the lineal feet of joists by their unit of volume and adding thereto the concrete in the thin slabs.

The cubic feet of concrete per square foot of floor (or roof) area of Ceco steelform construction, is a function of the thickness of the thin slab, the depth of the joists, and the width and spacing of the joists. The additional concrete in the joists at their ends as formed by tapered endforms cannot be pro-rated on a square foot basis. The concrete added to the joists by the tapered endforms must be figured per lineal foot of beam or wall into which the joists frame, and this unit of volume must be multiplied by the number of lineal feet of beams and walls along which the

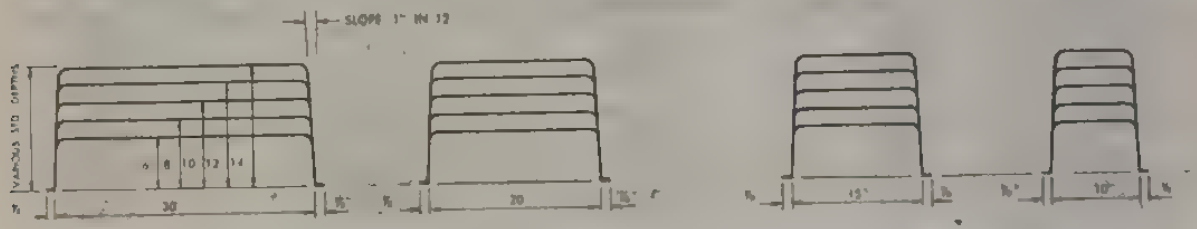
*The Ceco Corporation.

tapered endforms are set, to determine the total amount of concrete added by the use of the tapered endforms.

For convenience in estimating, an arrangement in tabular form of the quantities of concrete required for Ceco Flange Type Steelform construction, is given on the following pages. In this connection it is well to bear in mind that the strength of the metal of which Ceco Steelforms are made permits sharp angles in the steelforms and an absolutely flat top, thus requiring a minimum of concrete. These tables should, therefore, not be used in computing the concrete for other types of metal form construction.

Typical Cross-sections of Flangeforms

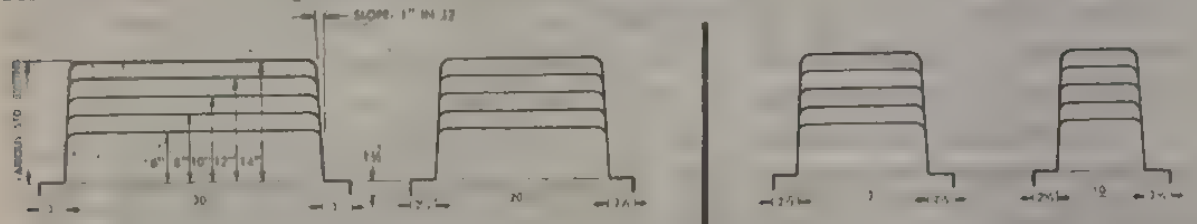
All Dimensions Are Outside To Outside



Sizes of Ceco Flange Type Steelforms

Typical Cross-sections of Longforms

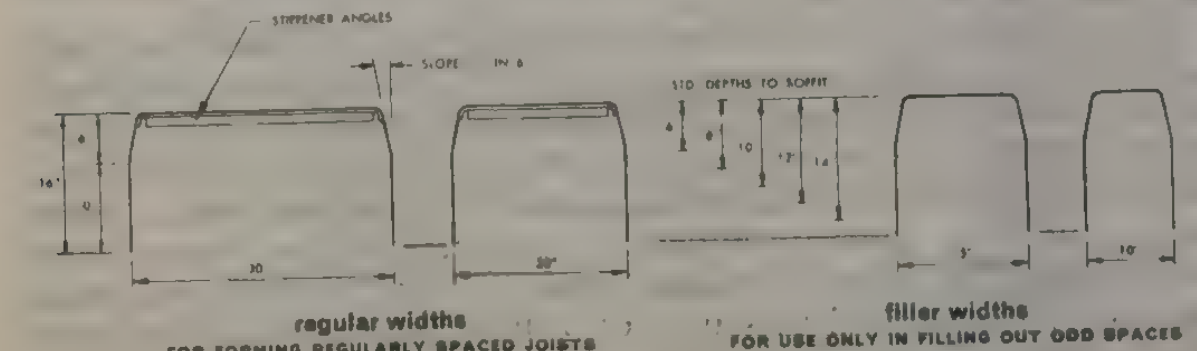
All Widths and Depths Are Outside Dimensions



Sizes of Ceco Longform Steelforms

Typical Cross-sections of Adjustable Steelforms

All Dimensions Are Outside To Outside



Regular Widths Filler Widths

Sizes of Ceco Adjustable Type Steelforms

Concrete Required per Sq. Ft. of Floor Using Ceco† Flange** Type Steelforms 20 Inches Wide

Depth of Steelform	Width of Joist	Cubic feet of concrete per sq. ft. of floor with slab thickness over steelforms of 2″	2½″	3″	Additional concrete required (in cu. ft.) per lin. ft. of beam or bearing wall where standard tapered endforms are used*
6″	4″	.262	.304	.346	.13
	5″	.279	.321	.363	.12
	6″	.293	.335	.377	.12
8″	4″	.298	.340	.382	.17
	5″	.320	.362	.404	.16
	6″	.339	.381	.423	.16
10″	4″	.336	.378	.420	.21
	5″	.363	.405	.447	.20
	6″	.387	.429	.471	.19
12″	4″	.377	.419	.461	.25
	5″	.408	.450	.492	.24
	6″	.437	.479	.521	.23
14″	5″	.456	.498	.540	.28
	6″	.490	.532	.574	.27
	7″	.522	.564	.606	.26
16″	5″	.507	.549	.590	.32
	6″	.545	.587	.629	.31
	7″	.581	.622	.664	.30

Concrete Required per Sq. Ft. of Floor Using Ceco† Flange** Type Steelforms 30 Inches Wide

Depth of Steelform	Width of Joist	Cubic feet of concrete per sq. ft. of floor with slab thickness over steelforms of 2½″	3″	3½″	Additional concrete required (in cu. ft.) per lin. ft. of beam or bearing wall where standard tapered endforms are used*
6″	5″	.293	.334	.376	.11
	6″	.304	.346	.387	.11
	7″	.315	.357	.398	.11
8″	5″	.322	.364	.405	.15
	6″	.338	.380	.421	.15
	7″	.351	.392	.434	.14
10″	5″	.353	.395	.436	.19
	6″	.372	.414	.455	.18
	7″	.389	.430	.472	.18
12″	5″	.386	.427	.469	.22
	6″	.408	.450	.491	.22
	7″	.430	.470	.512	.21
14″	5″	.420	460	.503	.26
	6″	.447	.488	.530	.25
	7″	470	.511	.553	.24
16″	5″	.451	.493	.535	.29
	6″	.482	.523	.565	.28
	7″	.510	.552	.594	.27

*Amount of Concrete Given for Standard Tapered Endforms is for One Side of Beam Only.

** The above concrete requirements are also applicable to one piece longforms.

†The Ceco Corporation.

Concrete Required per Sq. Ft. of Floor Using Ceco* Adjustable Steelforms 20 Inches Wide

Depth of Steelform	Width of Joist	Cubic feet of concrete per sq. ft. of floor with slab thickness over steelforms of 2"	2½"	3"	Additional concrete required (in cu. ft.) per lin. ft. of beam or bearing wall where standard tapered endforms are used **
6"	3½"	.262	.304	.345	.13
	4½"	.279	.321	.362	.12
	5½"	.295	.337	.378	.12
8"	3½"	.289	.329	.370	.17
	4½"	.309	.350	.393	.16
	5½"	.331	.372	.414	.16
10"	3½"	.312	.353	.395	.21
	4½"	.340	.381	.424	.20
	5½"	.367	.408	.450	.19
12"	3½"	.336	.378	.420	.25
	4½"	.371	.412	.455	.24
	5½"	.403	.444	.486	.23
14"	3½"	.361	.403	.444	.29
	4½"	.402	.443	.485	.28
	5½"	.438	.480	.522	.27

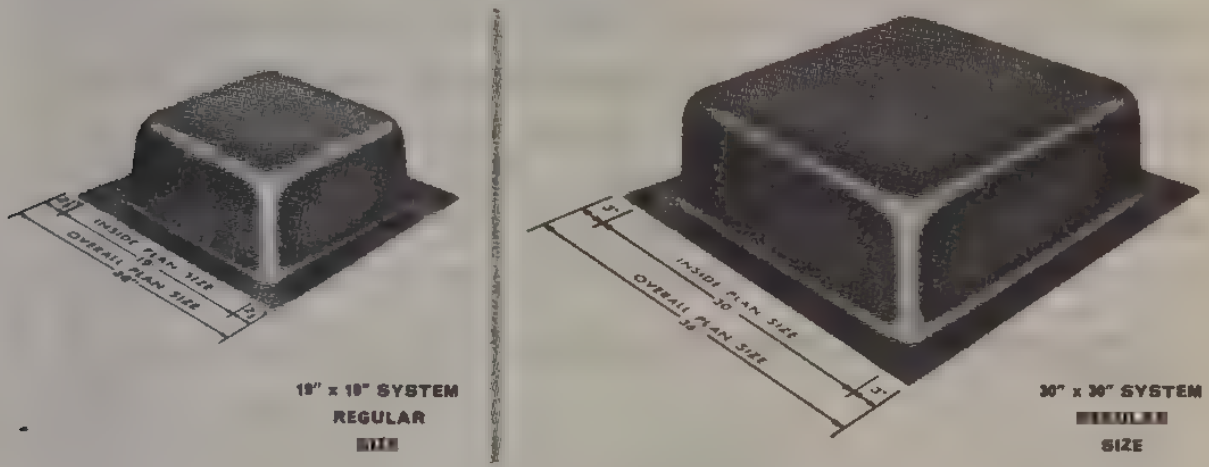
Concrete Required per Sq. Ft. of Floor Using Ceco* Adjustable Steelforms 30 Inches Wide

Depth of Steelform	Width of Joist	Cubic feet of concrete per sq. ft. of floor with slab thickness over steelforms of 2½"	3"	3½"	Additional concrete required (in cu. ft.) per lin. ft. of beam or bearing wall where standard tapered endforms are used **
6"	5½"	.300	.341	.383	.11
	6½"	.311	.353	.395	.11
	7½"	.322	.364	.406	.11
8"	5½"	.326	.368	.408	.15
	6½"	.341	.383	.424	.15
	7½"	.355	.397	.438	.14
10"	5½"	.352	.394	.434	19
	6½"	.371	.413	.454	.18
	7½"	.389	.430	.472	.18
12"	5½"	.378	.420	.461	.22
	6½"	.401	.443	.484	.22
	7½"	.422	.464	.505	.21
14"	5½"	.404	.446	.486	.26
	6½"	.430	.472	.514	.25
	7½"	.456	.497	.539	.24

*The Ceco Corporation.

**Amount of concrete given for standard tapered endforms is for one side of beam only.

Ceco* One Piece Steeldomes for Two-Way Dome Slab Construction.—To estimate the quantity of concrete required for steeldome construction, figure the concrete required for a solid slab of the depth of the dome plus the top slab, and subtract the voids created for each steeldome as given in the table below.



Ceco Steeldomes

Steeldome Sizes

19" x 19" SYSTEM		30" x 30" SYSTEM	
Item	Standard Size	Standard Size	Filler Sizes
Plan Size of Void	19" x 19"	30" x 30"	20" x 30" and 20" x 20"
Overall Plan Size Including Flanges	24" x 24"	36" x 36"	26" x 36" and 26" x 26"
Width of Flange	2½"	3"	3"
Depths of Domes	4", 6", 8", 10" & 12"	8", 10", 12", 14" 16" & 20"	8", 10", 12", 14", 16" & 20"

Typical Ceco Steeldome Sizes

Table of Concrete Voids

VOIDS CREATED BY STEELDOME, CUBIC FEET				
Depth of Steeldome	19" x 19" SYSTEM	30" x 30" SYSTEM		
	Regular 19" x 19"	Regular 30" x 30"	Fillers	
			20" x 30"	20" x 20"
4"	0.77			
6"	1.09			
8"	1.41	3.85	2.54	1.65
10"	1.90	4.78	3.13	2.06
12"	2.14	5.53	3.63	2.41
14"		6.54	4.27	2.87
16"		7.44	4.85	3.14
20"		9.16	5.90	3.81

Table of Concrete Voids for Ceco Steeldomes

*The Ceco Corporation.

FORMS OTHER THAN WOOD

Corruform*—Lightweight Steel Forming Material for Concrete

Corruform is a high-strength corrugated steel forming material for reinforced concrete floor and roof slabs. It comes in three weights—Standard Corruform, Heavy Duty Corruform and Extra Heavy Duty (Tufcor), either galvanized or uncoated. Manufactured from 100,000 p.s.i. tough-temper steel. Corruform has a definite reliable structural strength nearly twice that of ordinary steel having equal weight. Used primarily in floor and roof systems having steel joists, junior beams, or purlins it is also used

*Corruform is a trade mark of Granco Steel Products Company, Reg. U. S. Pat. Off.

Placing Corruform Floor Panels.

over pipe tunnels or similar installations where economies of using permanent forms can be realized. Either structural grade concrete or lightweight, insulating concrete may be used with Corruform but in either case reinforcing bars or wire mesh should be added to satisfy flexure and temperature steel requirements.

Corruform offers many advantages over other methods of flexible centering. The light, rigid sheets are quickly placed. No side pull is exerted on joists, instead, joist top chords are given lateral support by the stiffness of the material. Sheets in place provide a safe working platform. Mesh is easily and effectively placed. Elimination of sag between joists reduces concrete quantity. All paste is retained in slab. Uniform thickness of slab over joists and mid span permits monolithic finish. No cleanup is required underneath.

Corruform for exposed construction, is available galvanized. For unexposed joist construction it is available uncoated.

Corruform sheets are placed with corrugations normal to the supporting joists or beams with the end lap of sheets occurring over the joists or beams. The sheets are placed with edge lips up and are lapped a minimum of one corrugation with adjacent sheets. The ends of sheets should lap a minimum of 2". The sheets

Exposed Ceiling of Corruform.

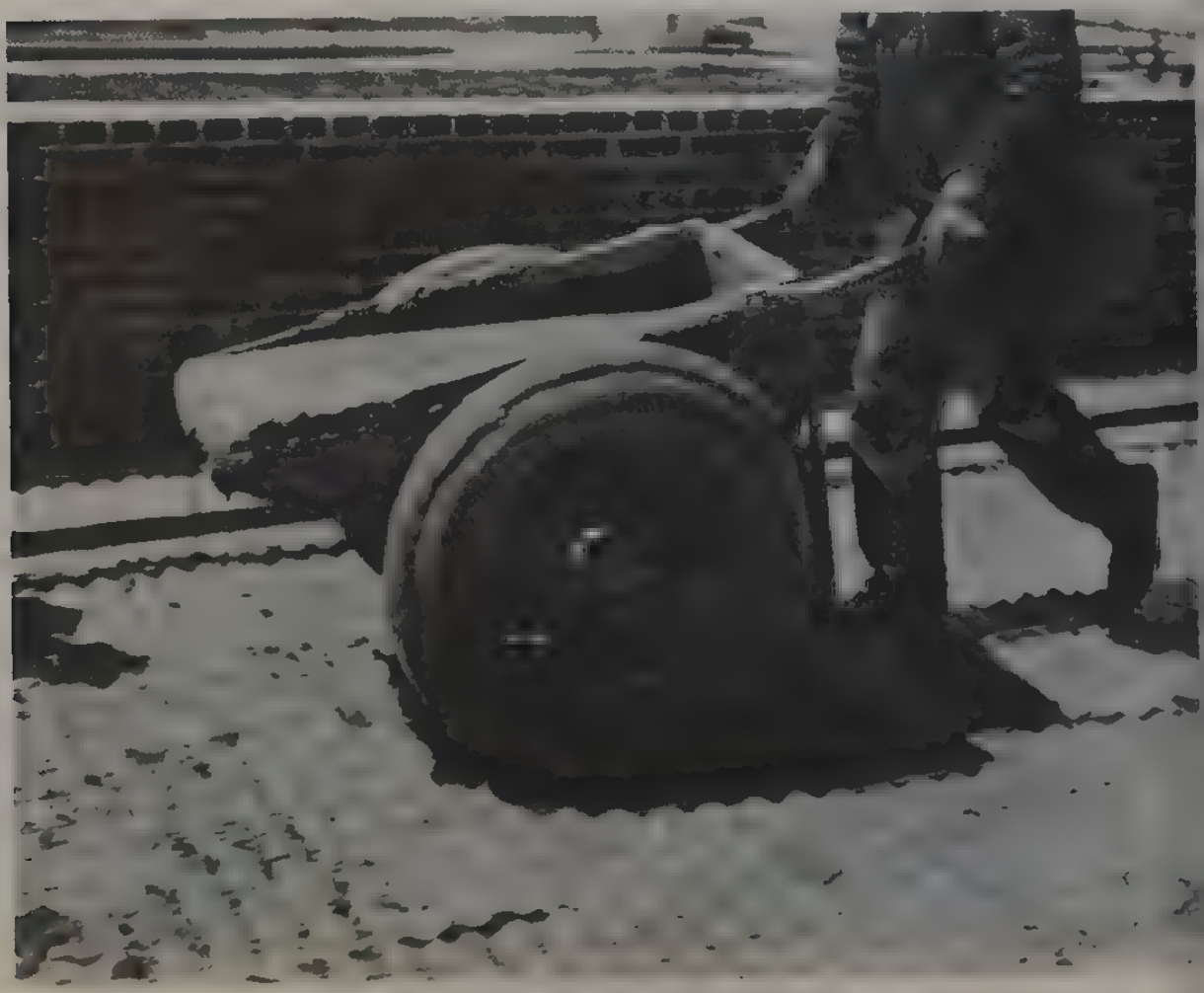
are fastened to the supporting members by means of clips, arc-welding or by nailing. For steel joist construction the most satisfactory method of attachment is arc-welding. The manufacturer provides special curved washers for use in welding the sheets to the steel framework that provide for fast, high-strength welds.

Estimating.—Corruform is sold to contractors by the manufacturer directly, or through a national distributor organization. The material is sold by the square with the area determination based on sheet width times actual sheet length.

Table of Standard Lengths

Product	Cover	Standard Lengths
Std. Corruform	30″	6′-3″ to 31′-9″ in 6″ increments
H. D. Corruform	28″	7′-2″ to 32′-0″ in 4″ increments
Tufcor	32″	7′-2″ to 32′-0″ in 4″ increments

The cost of standard Corruform delivered to job site on an aver-



Wheeling Concrete Buggies over Corruform.

age size carload lot (540 squares or more) is $10.00 for uncoated to $15.50 per square for galvanized plus actual freight charges. Smaller quantities will take warehouse price of $3.00 to $4.00 more per square. Corruform weighs 78 pounds per square for uncoated and 88 pounds per square for galvanized.

Erection Costs.—Corruform can be rapidly erected in all kinds of weather thereby providing cover to floors below. The Corruform sheets are large in area but extremely light in weight and can be easily handled by one man.

A well organized crew, working under favorable conditions, can place and fasten up to 10,000 square feet of Corruform per eight hour day, but most jobs will average 3,000 to 5,000 square feet per day.

Using an average figure of 4,000 square feet per eight hour day for a four man crew, the labor costs for placing 1,000 square feet of Corruform would be as follows:

	Hours	Rate	Total	Rate	Total
Ironworker	8	$.....	$.....	$7.10	$56.80
Cost per sq. ft.....			.....		.568

The above figures are based upon one man welding or fastening

Distributing and Placing Cofar Floor Panels.

the deck in place and three men handling and placing the material. Costs do not include overhead and profit.

Computing Concrete Quantities.—When computing volume of concrete placed over Corruform decking, subtract ¼-in. from slab thickness to allow for corrugations of standard Corruform and ⅜-in. for heavy duty Corruform. Size of corrugations; standard, ½-in. depth x 2 3/16-in. pitch; heavy duty, ¾-in. depth x 3-in. pitch.

Cofar* Combined Form and Reinforcing Units

Cofar combined form and reinforcing units are used for floor and roof construction. They eliminate both the slab wood forms and the conventional reinforcing steel used in the bottom of slabs. Cofar consists of a high strength, deep corrugated steel sheet with transverse wires welded to it at each corrugation. The high strength steel provides excess strength for both its reinforcing and form function and also provides the units with the ability to absorb extreme construction abuses without permanent damage. The corrugated steel sheets are specification galvanized with a

Placing Cofar Floor Panels.

*Cofar is a trade mark of Granco Steel Products Company, Granite City, Ill.

1¼ oz. per sq. ft. coating class to impart a high degree of permanency to the product.

The Cofar units provide an immediate platform, allowing all trades to move in and out quickly. The smooth, corrugated underside of the units provide an attractive ceiling for those cases where plaster or acoustical ceilings are not required. All Cofar units are sent to the job pre-cut to fit the building frame. Minor cutting at columns, etc. is done in the field. The manufacturer also supplies complete drawings for use in correct placement of material.

The basic components of Cofar reinforced floor or roof slabs consist of the Cofar units, structural concrete, negative (top steel) reinforcing steel over the permanent supports, and support members for holding the negative steel at the correct elevation within the slab. The units and accessories for the support of negative reinforcing are supplied by the manufacturer. Erection of the units, and the furnishing and placing of the concrete and reinforcing materials are the responsibility of the general contractor. Cofar units can be used in all types of construction, heavy or light loading, and may be used in both concrete frame and masonry wall construction as well as in steel frame construction. When used on steel frame construction the units are placed on the supporting beams and attached to them by means of plug welding through special welding washers supplied by the manufacturer. For use on concrete frame construction the units are placed on the formwork for the supporting members and fastened thereto by means of double-headed nails.

The manufacturer supplies a saw-tooth type of closure to prevent concrete leakage when the concrete supports are to be integrally cast with the slab. These closures are nailed to the inside of the formwork at the ends of the units and are stripped with the forms. Cofar units can only be used on spans up to 24′-0″ as manufacturing limitations prohibit longer lengths of the units. The units will adequately carry the wet concrete and construction loads on spans up to 7′-0″ without additional supports. For spans from 7′-0″ to 10′-0″ one row of temporary support ledgers are required. For spans 10′-0″ to 14′-0″, two rows of temporary support ledgers are required. Three rows of temporary supports are required for spans from 14′-0″ to 18′-0″.

After the units have been installed and after the electrical, mechanical, and other trades have finished their work, the negative reinforcing and the supporting accessories are put in place. All negative reinforcing generally consists of short, straight bars that are easily and quickly placed at the correct spacing. The

placing of concrete and finishing of the slab are the next and final operation. Concreting operations are the same as for conventional formed and reinforced concrete floor slabs.

Both the form and reinforcing function of the Cofar units are performed by the corrugated steel sheets of the units. The corrugated sheets support the wet concrete and construction loads by flexural action. The reinforcing function of the corrugated sheets are made possible by the transfer of horizontal shearing stress from the concrete through the welds which fasten the transverse wires to the sheets. The concrete completely encases the transverse wires and transfers its stress through the wires to the welds by bearing against the wires. The transverse wires, besides serving to transfer the horizontal shearing stress also serve as temperature reinforcement.

Cofar reinforced slabs have been used on many types of building construction including fireproof office buildings, dormitories, residences, pipe tunnels, schools, grandstands and auditoriums, warehouses, and heavy industrial buildings. The use of Cofar reinforced slabs in conjunction with standard electrical under-

Placing Concrete Over Cofar Floor Panels.

floor systems provides economical floor construction where underfloor electrification is desired.

Estimating.—Cofar units are generally sold through a national distributor organization, or direct to contractors.

The manufacturer's quotation will include provisions for all accessories and engineering services provided by him and will give tonnage and square footage information that will enable contractor to figure cartage and installation costs. Cover area of Cofar units are usually based on center to center of supports for steel construction and on clear distance between beams and girders plus 2" for bearing on concrete frame construction.

The cost of the Cofar units delivered to job site in midwestern area on an average size carload lot job (200 squares or more) is usually between 41 to 46 cts. per sq. ft. for most projects. These prices are based on 24 gauge corrugated material, as this material will satisfy most normal loading requirements. For projects where extremely heavy loadings are specified, either 22 gauge or 20 gauge material is usually required. The costs of these heavier gauges could increase the above costs 15 cts. a sq. ft. in the most extreme cases. Smaller quantities will take warehouse price of 4 to 5 cts. more per square foot.

Erection.—The cost of labor handling and placing Cofar units is usually estimated on a sq. ft. basis. This cost will vary somewhat depending on the size of the building, length of span, amount of handling necessary, type of construction and the gauge of steel, etc.

All units are given mark numbers in the shop and are placed in accordance with placement drawings provided by the manufacturer. An advantage of the Cofar units is the fact that a large area can be covered very quickly and the units immediately provide both a protective staging and a working platform.

On steel frame construction, a well organized crew can place up to 6,000 square feet of the units per 8 hour day. An average size erection crew consists of four men. Since most jobs call for the units to be welded in place, one welder is required and the other three men carry and place the units in position. On multistory buildings hoisting equipment and labor is also required. The units are shop bundled in convenient lifts for easy hoisting. The placing costs for Cofar units usually include unloading at job site and hoisting or carrying bundles to position, placing and welding or fastening the units into place. The placing costs on concrete frame buildings are usually somewhat higher than for steel frame, as the cost of placing the saw-tooth closure strips must be added into the total cost.

Supporting Cofar Forms on Long Spans.

Computing Concrete Quantities.—When computing volume of concrete placed over Cofar decking, subtract ⅜-in. from slab

thickness to allow for corrugations. Size of corrugation is $1\frac{5}{16}$-in. depth x $4\frac{9}{16}$-in. pitch.

Actual Costs for 20 Story, Steel Frame Office Building.—On a 20 story office building the actual placing costs for 1,000 sq. ft. were as follows:

Unloading & Hoisting	Hours	Rate	Total	Rate	Total
Ironworker	6.90	$.....	$.....	$7.10	$48.99
Placing & Welding Units					
Ironworker	5.10	.....	.....	7.10	36.21
Cost per 1,000 sq. ft.	12.00		$.....		$85.20
Cost per sq. ft.					.852

Unloading and hoisting costs include unloading at storage site, reloading onto trucks and unloading and hoisting at jobsite, including equipment.

The above costs were based on ironworkers handling the material and are actual field costs and do not include overhead and profit.

Actual Costs for Three Story, Concrete Frame Building.—On a project where the Cofar units spanned 14'-0", 5'-0" and 14'-0" on three similar floors, the placing costs per 1,000 sq. ft. were as follows:

Unloading & Hoisting	Hours	Rate	Total	Rate	Total
Ironworker	5.2	$.....	$.....	$7.10	$ 36.92
Placing & Fastening					
Ironworker	8.9	.....	.....	7.10	63.19
Cost per 1,000 sq. ft.	14.1		$.....		$100.11
Cost per sq. ft.			.....		.100

Above costs are based on ironworkers installing the Cofar units and are actual field costs and do not include overhead and profit.

Placing Negative Reinforcing, Temporary Supports, Concrete.—The costs for placing the negative reinforcing steel and supporting accessories as well as the concrete placing and finishing costs should be figured as for normal reinforced concrete construction. It should be remembered, however, that normal clean up costs and rubbing and patching costs are almost completely eliminated. The cost of placing the negative reinforcing will also be minimized due to the usage of straight bars of short lengths.

Temporary supports for use with long span Cofar construction can be built of wood or prefabricated steel. Typical wood ledgers and wood shoring can be used on all jobs. Larger jobs make the use of adjustable shores and prefabricated steel ledgers feasible. Since the temporary supports are not subject to usual abuse of concrete formwork they can be reused a greater number of times.

METAL LATH CENTERING—FORM AND REINFORCING

Metal lath laid across and attached to the top of open web steel joists, junior beams, structural steel purlins, or wood or concrete joists, provides an economical form for short span floor and roof decks. Since the supporting framework is the structure itself, and no shores or solid decks are required for the construction, this style of formwork is commonly called "centering," similar to the terminology given to falsework supporting flat tile arches. Metal lath is a permanent installation and not a falsework support for wet concrete or lightweight roof fills. It is not removed after the concrete has set. The openings in the lath result in its embedment in the underside of a completed slab, due to the actions of placing and spreading the wet concrete. Thus, without the need for working concrete under and around reinforcing bars, or vibrating and tamping, a measure of reinforcing steel is provided in the bottom face of the slab where tensile forces are greatest.

Installation.—On most jobs the lath is installed rapidly by one or two men soon after the framework has been placed. The sheets of lath are laid across the supports with ribs pointing upward, so that they will become thoroughly embedded in the concrete. Individual sheets are joined along the sides to adjacent sheets by "nesting" the ribs at the outer edges, and such nestings are wire tied at each support and between each support. Where the ends of two sheets join between supports, they are lapped at least 4", the ribs are nested, and each rib nesting is wire tied. In fastening sheets to supports the laths are tied, clipped or otherwise securely fastened, without stretching, at every other rib. Where the ends of two sheets join over a support, they are lapped at least 3", and every other nesting is fastened to the support.

Spans of Lath.—In the majority of cases the limits of distance between supports for a given weight of metal lath is determined by the load of wet concrete it must support. When the concrete has reached strength, the combination of concrete and metal lath reinforcement will safely sustain a total load far greater than the initial weight of wet concrete. However, it is seldom expedient to attempt to realize the full design capacity of the lath as a reinforcement, for the increased spans of lath would make it necessary to install temporary supports between the structural members until the concrete had hardened.

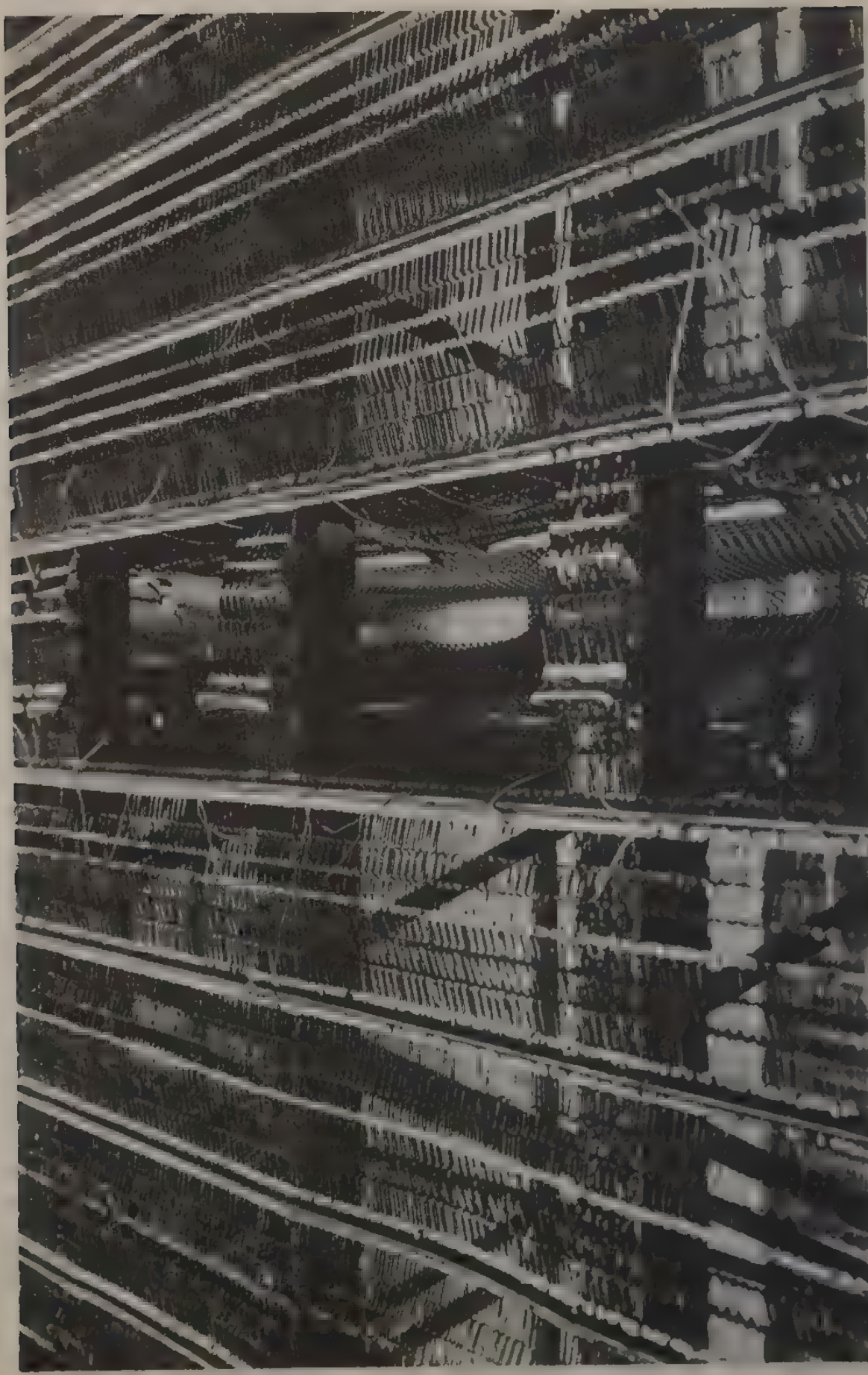
The following table gives maximum spans for centering wet concrete. For greater spans, temporary supports are necessary.

Thickn. of slab	3/8" rib lath 3.4 lbs.	3/8" rib lath 4.0 lbs.	Sheet Lath 4.5 lbs.	3/4" rib lath 0.60 lbs.	3/4" rib lath 0.75 lbs.
2 "	2'-0"	2'- 0"	2'-6"	3'- 3"	3'- 7"
2½"	2'-0"	2'- 0"	2'-3"	2'-11"	3'- 3"
3 "	2'-0"	2'- 0"	2'-0"	2'- 8"	2'-11"
3½"	1'-9"	1'-10"	2'-0"	2'- 5"	2'- 9"
4 "	1'-6"	1'- 8"	1'-9"	2'- 3"	2'- 6"

Weights of lath are in lbs. per square yard except for 3/4" rib laths which are given in lbs. per square foot.

Other Functions.—In addition to providing a form for a floor or roof slab, the lath may be cut and bent to form bulkheads, sloped ramps, encasements for the ends of joists at bearing walls, and encasement of supporting steel beams and girders. All of these functions are provided by bending the lath either upwards or downwards to contours such that the desired shape is obtained when the concrete is placed on the centering itself. Stiffener bridging, or T-beams, running perpendicular to the line of joists, may be provided as part of the deck assembly. Such bridging is usually specified for steel joists spanning 15 feet or more, although it is also fused under the line of transverse partitions supported on the slab. The forming of these T-beams is accomplished by installing a "trench" in the centering. The trench is formed by bending 3" to 4" flaps of adjoining sheets down into the joist space, after cutting these sheets along each side of each joist. To the flaps is attached an open-top trough usually formed by bending sheets of diamond mesh metal lath along the length of the sheet. The trough, which will serve as a combined form and reinforcement for the sides and bottom of the T-beam, passes through the opening in the web of each joist which it crosses. The folded, sheet-length sections of this trough are guided through the openings in the joists, allowed to spring open, and are wire-tied to the flaps of rib lath centering. Ends of the sections are lapped and tied together. There is no tie between the completed trough and the steel joists.

Concrete Consistency.—When wet concrete is placed and worked on metal lath centering, the concrete is forced partway through the openings of the lath to an extent which is largely dependent upon the water content of the concrete. It can vary from a slight bulging—for a dry but workable mix—to probable leakage, where high slump concrete is used. The slump of most ready-mixed concretes is 4" to 5" for all design strengths when leaving the batch plant, unless a different slump has been specified. However, the mix may become slightly stiff en route or water may be added. The probable maximum range of slump for delivered



Forming a T Beam in Metal Lath Centering

ready-mixed concrete is 2″ to 8″. A mix suitable for placement over metal lath centering will have a slump of approximately 2½″, but no more than 3″. Concrete containing air entraining agents can be worked satisfactorily when its slump is as low as 2″. Another method of improving workability of low slump concretes is to use smaller size or rounded aggregates.

The mere spreading of a properly mixed concrete, having a 2½″ to 3″ slump, will force it through the openings in metal lath sufficiently to embed the metal and to "key" the top of supporting members. If excessive water has been added to the mix, that fact can readily be detected due to the seepage which will occur.

OTHER CONSIDERATIONS

When preparing a bid inclusive of this style of centering, the estimator should be aware of circumstances which might add to his other costs, thereby offsetting at least a portion of the savings which he had anticipated.

Negative Reinforcing.—If the surface of the slab is not to be tiled, floored, or otherwise covered, it is sometimes necessary to add reinforcing in the top surface of the concrete to resist negative moments over the supports. These moments may become great enough to induce lines of stress-relief cracks in the top of the concrete. Although the slab will remain structurally sound, its appearance will have been impaired. Negative reinforcing is usually designated on the drawings or in the specifications, and the careful estimator is not apt to miss it. However, for those once-in-a-while jobs where the subject has been left open, the following table lists maximum live loads, in lbs. per sq. ft., for continuous span slabs containing metal lath centering, above which loads the slab may be subject to stress relief cracking.

Safe Live Loads (lbs. per sq. ft.) Without Negative Reinforcement

Thickness of Slab	Span of Metal Lath Centering			
	19″	24″	30″	36″
2 ″	134	75	39	19
2½″	218	126	69	38
3 ″	325	189	108	65
3½″	445	263	152	91
4 ″	587	350	206	128

Undercoating.—If the bottom surface of the deck is to be the ceiling of inhabited portions of the completed structure, the specifications will probably include plastering the underside of the slab. This is normally done with ½″ of portland cement plaster.

Such work is usually included in the plaster work specifications, but—on some projects the estimator may find this item included in the concrete work.

Concrete Quantities.—In listing quantities of concrete, the estimator must allow for more than is indicated on the drawings. On the average, ¼" of concrete will be required in addition to the specified slab thickness, due to the final embedment of lath in the concrete. Further, the weight of wet concrete will slightly depress the metal lath centering between the supports. The depression due to weight of wet concrete varies from 0" at the supports to as much as ½" at mid-span of the lath. It can be greater, of course, if reasonable care is not exercised during placement of concrete. Experienced workmen will place wet concrete and other loads so as to center on the supports, which are readily visible through the metal lath centering. It is common practice to compensate for both the embedment factor and the "sag" factor by adding ½" to the specified slab thickness.

Job Damage.—As with any system of forms for reinforced concrete, plank walkways should be provided for movement of materials. Otherwise, excessive abuse of metal lath centering may result in the need for additional concrete.

Clean Up.—If concrete of 2½" to 3" slump will not be used, allowance should be made for some means of cleaning paved areas below. Some contractors accomplish this by spreading sand, tarpaulins, building paper, or other coverings. Usually, no protection or cleanup is necessary, even where concrete with 5" or 6" slump is used, when the lower floor areas are not finished. These lower areas may be left unpaved or if rough slabs have been placed—paper cover for curing purposes may be left in position until decks above have been completed. Another method of minimizing cleanup of high slump concrete is to place concrete from the top floor down, in multi-story buildings, having first installed the metal lath centering on all floors.

LABOR APPLYING METAL LATH CENTERING

Centering.—In applying metal lath centering, including handling bundles of lath, placement of sheets, wire-tying sheets to each other and to support members, forming bulkheads, ramps, and encasements for ends of joists, two lathers working together should cover 2500 to 3000 sq. ft. of deck per 8-hr. day.

T-Beams and Beam Encasement.—The work of cutting, shaping and fitting the components for T-beam bridging and for "caging-in" supporting beams is usually performed by one lather working alone, after the deck has been lathed and all material is

at hand. The operation should proceed at an average rate of 60 lin. ft. of "cage" per 8-hr. day.

Negative Reinforcement.—When supplemental reinforcing is required, it is not installed by the lather. The estimator should use the labor rates suggested on page 276, for tied-in-place, light reinforcing bars, keeping in mind, that short pieces of straight bars are more easily handled than long, bent, truss bars.

Undercoating or Plastering.—Where plastering of the underside of completed slabs is required, refer to Chapter XVIII, page 1182, for labor of applying portland cement plaster. Figure same as for interior work on brick, clay tile or cement block except reduce thickness from ¾" to ½" and omit application of scratch coat.

Placing Concrete.—On most installations of metal lath centering, cement finishers and laborers have only to deposit concrete, level it, and finish the surface. There is no need to work concrete under and around reinforcing steel and, of course, there is no vibrating and tamping. However, the need for low slump concrete sometimes requires more work by the finishers, or—where concrete of medium consistency (5" to 6" slump) is used—the laborers may be required to clean floor areas below. The estimator must weigh these and other factors before deciding on the productivity rates for the placement of concrete on metal lath centering. The operations of hoisting and wheeling concrete to the deck are the same as for ordinary reinforced concrete construction of relatively thin floors, see pages 443-453. Placing and leveling operations can vary from 1 to 2 man-hours per 100 sq. ft. Also, when maximum placing and (high slump concrete) leveling rates may be used, additional cleanup labor is sometimes necessary. This can vary from 0 to 1 man-hours per 100 sq. ft. with the extra cost allocated entirely to concrete work or to concrete and plastering.

Material Prices, Metal Lath.—For unit cost of metal lath, consult Chapter XVIII, page 1184. Figure quantities of ⅜" rib lath by dividing the floor area by 9 sq. ft. for each sq. yd. and add 10% to the yardage to cover such items as lapping, bulkheading and encasements. The heavier ¾" rib lath is sold by the square foot, and comes in a variety of sheet sizes. The estimator should select sizes which will minimize cutting. Quantity requirements will usually be 10% more than the floor area. For "cages" around supporting beams or for T-beams bridging, figure individual requirements of diamond mesh metal lath by computing the size of cages or baskets which will be required. Keep in mind that sheets of lath are 24" or 27" wide x 96" in length.

Tie Wire.—Requirements of 18 ga. galvanized tie wire, normally used to fasten sheets of metal lath to each other and to the supports, will vary with the spacing of joists. In a typical installation of open web steel joists spaced 24" on centers, approximately 10 lbs. of wire will be used for each 1000 sq. ft. of area. This wire is available from local warehouse stock, usually in 25 lb. bundles costing about $30.00.

Concrete.—Usually, the estimator will figure local prices for the particular strength of concrete which has been specified for slabs. However, he may wish to consider the use of concrete containing air entraining agents or smaller-than-normal aggregate. These devices will be beneficial to cement finishing costs but, in some areas, may influence the price of the concrete.

Miscellany.—Miscellaneous items of material, which may be required on a metal lath centering job, should be added to the estimator's check list. They include: planking for catwalks, supplemental reinforcing steel, gunite or portland cement plaster. If allowing sand or tarpaulins for finished areas below, do not duplicate under plasterwork. If allowing paper cover for slabs below, do not duplicate under curing of those slabs.

Cost of 1000 Sq. Ft. of 3" Concrete Slab on 4.0 Lb. ⅜" Rib Metal Lath Centering—Steel Joists 24" on Centers

	Hours	Rate	Total	Rate	Total
120 sq. yds. rib metal lath (6 bundles of sheets 27"x96", 10 sheets per bundle)	.....	.....	.....	$ 0.75	$ 90.00
10 lbs. tie wire	.....	.....	.....	.30	3.00
Catwalks—allowance	.....	.....	.....	.....	15.00
Lathers	6.0	.....	.....	6.50	39.00
10-¾ cu. yds. 3000 lb. ready mix*	.....	.....	.....	20.00	215.00
Labor*	5.5	.....	.....	5.00	27.50
Hoisting engineer	1.3	.....	.....	6.00	7.80
Cement mason*	19.5	.....	.....	6.50	126.95
Cost per 1000 sq. ft.	32.3		$		$524.25
Cost per sq. ft.					.524

* Price given for concrete is average for standard mix, having 3" slump. For concrete with 5" to 6" slump, reduce cement mason labor by 4-5 hours; also, with high slump concrete, if cleanup of areas below is required, add 4-5 hours to labor, and add for sand, tarpaulins or paper. Cleanup labor and materials may be apportioned between concrete, curing, and plastering, if desired.

Cost of 1,000 Sq. Ft. of 2" Concrete Slab on 3.4 Lb. ⅜" Rib Metal Lath Centering—Steel Joists 24" on Centers

	Hours	Rate	Total	Rate	Total
120 sq. yds. rib metal lath.	.....	.....	.....	$ 0.70	$ 84.00
10 lbs. tie wire	.....	.....	.....	.30	3.00
Catwalks—material allowance	.....	.....	.....	.....	15.00
Lathers	5.5	.....	.....	6.50	35.75
8 cu. yds. 3000 lb. ready mix*	.....	.....	.....	20.00	160.00
Labor*	4.1	.....	.....	5.00	20.50
Hoisting engineer	1.0	.....	.....	6.00	6.00
Cement mason*	14.5	.....	.....	6.50	94.25
Cost per 1000 sq. ft.	25.1		$		$418.50
Cost per sq. ft.					.419

*See notes above.

Cost of 1000 Sq. Ft. of 2½" Concrete Slab on ¾" Rib Metal Lath Weighing 0.75 Lbs. Per Sq. Ft.—Steel Joists 36" on Centers

	Hours	Rate	Total	Rate	Total
1100 sq. ft. ¾" rib lath*	.....	.....	.....	$20.00	$220.00
5 lbs. tie wire	.....	.....	.....	.30	1.50
Catwalks—allowance	.....	.....	.....	.....	15.00
Lather	7.5	.....	.....	6.50	48.75
9¼ cu. yds. 3000 lb. air entrained concrete**	.....	.....	.....	20.00	185.00
Labor**	4.75	.....	.....	5.00	23.75
Hoisting engineer	1.1	.....	.....	6.00	6.60
Cement mason	16.75	.....	.....	6.50	108.88
Cost per 1000 sq. ft.			$		$609.48
Cost per sq. ft.					.609

* Sheets of ¾" rib lath are available either 24" or 29" wide, by 8', 10' or 12' long. The estimator should plan his purchases so as to keep cutting to the minimum.

** Allowances are based on use of concrete having 2½" slump. Workability is about the same as for non air-entrained concrete having 3½" slump. If concrete having 5" to 6" slump is to be used, delete any premium for A-E concrete, and reduce cement mason labor by 3.5 to 4.5 hours. If clean-up of areas below is required—add 4 to 5 hours to labor, and add for sand, paper or tarpaulins, either in total or as share of other portions of the work.

Labor Mixing and Depositing Reinforced Concrete

The labor cost of mixing and placing concrete for all classes of reinforced building work, such as columns, beams, girders,

stairs, floor slabs, etc., will vary with the size of the job, the method used in handling the materials to the mixer, size and type of mixer used and the method of hoisting and placing the concrete.

The number of cu. yds. in the job is a big factor in the labor costs because it is not usually advisable to spend a great deal for plant and equipment, such as hoisting towers, spouts, conveying systems, bins, etc., on a job containing less than 2,500 cu. yds. while a job containing 10,000 cu. yds. would warrant such an expenditure and would enable you to place concrete at a much lower cost per cu. yd.

The various methods of handling, hoisting and placing concrete are fully discussed on the following pages.

Mixing Reinforced Concrete by Hand.—It is not advisable to mix concrete by hand that is to be used for reinforced work as the uniformity of the mix cannot be relied upon. Labor costs of mixing concrete by hand are given on page 310.

Plant and Equipment for Reinforced Concrete Jobs.—The various methods available for mixing and placing reinforced concrete are given under "Contractor's Tools and Equipment" (Chapter IV). Also refer to power buggy operation under "Labor Mixing and Placing Concrete" (Chapter VII).

Mixing and Placing Concrete on Small Jobs, Using a One Sack (6-S) Mixer and Wheelbarrows or Concrete Buggies.—On small reinforced concrete jobs of light construction, where the floors are of clay tile or metal pan and concrete joist construction or where metal joists are used, it is necessary to cover a comparatively large floor area to place a small amount of concrete. Jobs of this kind require considerable labor working the concrete around the reinforcing bars in the joists and spreading, grading and tamping a very thin floor slab, usually 2" to 3", as a floor using 8" tile and a 2" slab over requires only 1 cu. yd. of concrete to 85 sq. ft. of floor.

It is on buildings of this type that a small mixer can be used to advantage both as to convenience and economy.

Concrete for reinforced structures is usually mixed in the proportions of 1:1¾:2¾ for columns and 1:2½:3½ for beams, girders, and floor slabs. When mixed in 1:2½:3½ proportions, it requires 1 sack of cement, 2½ cu. ft. sand and 3½ cu. ft. of gravel or stone or 1½ sacks of cement, 3¾ cu. ft. sand and 5¼ cu. ft. gravel or stone for each batch.

While it is possible under favorable conditions to mix and discharge a batch about every 2 minutes, it is seldom done in actual practice, except for short periods, as there is always a

certain amount of time consumed washing out mixer, cleaning barrows or buggies, moving runways, etc., and this must all be included in the final cost.

On jobs containing less than 500 cu. yds. of concrete, it is seldom economy to construct a special tower for hoisting the concrete from the ground to the upper floors and for this reason an ordinary double cage material hoist is generally used. While this method costs a little more, it is not sufficient to offset the cost of erecting a special hoisting tower for such a small amount of concrete.

Where the concrete is discharged into wheelbarrows, the average barrow holds only 2 to 2½ cu. ft. of wet concrete, so it will require 3 to 4 barrows to remove each batch from the mixer. In hoisting the concrete, an allowance of 1 minute is made for placing barrow on hoist, hoisting to upper floor and removing the barrow. On this basis it requires about 3 min. per batch of 4½ to 7 cu. ft. of mixed concrete; 20 batches containing 3½ to 5 cu. yds. an hr. or 30 to 40 cu. yds. per 8-hr. day.

On jobs of this kind it is often possible to use an automatic hoist, operating two single cages at one time, without the use of a hoisting engineer.

On work handled in this manner, the gang will be distributed about as follows: 2 men wheeling stone or gravel; 2 men wheeling sand and cement; 1 man attending mixer; 3 men wheeling concrete barrows from mixer to hoist; 3 men wheeling concrete from hoist to place of deposit; 4 men dumping barrows, spreading, grading and tamping concrete; 1 man on miscellaneous labor, such as cleaning barrows and mixer, gathering and burning cement sacks, etc.; 1 hoisting engineer, if required; also 1 cement mason supervising work.

Based on an output of 5 cu. yds. per hr. the labor cost per cu. yd. should average as follows:

	Hours	Rate	Total	Rate	Total
Labor	3.2	$.....	$.....	$5.00	$16.00
Hoisting engineer	0.2	.....	.....	6.00	1.20*
Cement mason	0.2	.....	.....	6.50	1.35
Cost per cu. yd.	3.6		$.....		$18.55

*Add only if required.

If concrete buggies holding 6 cu. ft. of mixed concrete are used for handling the concrete from the mixer to the floor, the costs will be reduced somewhat, as it requires only 1 or 2 buggies to take an entire batch from the mixer instead of 3 or 4 wheelbarrows. This will speed up the hoisting time, eliminate 2

to 3 laborers and permit a batch about every 2½ minutes. This will enable the mixer to turn out about 6 cu. yds. an hr. or 48 to 50 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	2.33	$.....	$.....	$5.00	$11.65
Hoisting engineer	.17	.....	.....	6.00	1.02*
Cement mason	.17	.....	.....	6.50	1.11
Cost per cu. yd.	2.67		$.....		$13.78

* Add only if required.

If small power buggies are used for transporting the concrete from mixer, deduct about ¼-hr. per cu. yd.

Mixing and Placing Concrete on Light Constructed Jobs Using a Bucket Hoist and a One Sack (6-S) or a Two Sack (11-S) Mixer.—On high light constructed buildings having only 75 to 100 cu. yds. of concrete per story, which can ordinarily be poured by a small mixer in 1 to 2 days, it is advisable to hoist the concrete in a bucket, using either a mast tower, steel tubular hoist or an ordinary wood tower. The concrete should be discharged from the mixer into the hoisting bucket, hoisted to the floor where it is to be used and then distributed in wheelbarrows or concrete buggies.

The labor cost of erecting and dismantling the hoisting tower should be estimated separately, and not included in the cu. yd. cost of placing the concrete.

Under favorable conditions a mixer will discharge a batch in 2 minutes or 30 batches an hr. but the entire job will not average over 20 to 25 batches an hr. or 160 to 200 per 8-hr. day.

Based on a 1:2:4 mix, a 1½ sack batch in a 6-S mixer will contain about 7 cu. ft. of mixed concrete, while a 2-sack batch in a 11-S mixer will contain about 9 cu. ft. of mixed concrete.

Approximately the following men will be required to operate each mixer:

	6-S	11-S
Supplying mixer with stone or gravel	3	4
Supplying mixer with sand and cement	2	2
Man attending mixer	1	1
Labor on floor attending hopper and filling buggies	1	1
Wheeling concrete from hopper to place of deposit (Concrete buggies)	2	3
Wheeling concrete from hopper to place of deposit (wheelbarrows)	4	5
Dumping barrows or buggies, spreading, grading, tamping and vibrating concrete, moving runways, etc.	5	5

	6-S	11-S
Miscellaneous labor, cleaning mixer and barrows, cement sacks, general clean-up, etc.	1	1
Cement mason supervising	1*	1*
Hoisting engineer	1	1
Mixer engineer		1*

Using a one sack (6-S) mixer, concrete buggies, and based on 6 cu. yds. an hr. the labor per cu. yd. of concrete should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	2.50	$.....	$.....	$5.00	$12.50
Hoisting engineer	.17	.....	.....	6.00	1.02*
Mason or cement finisher	.17	.....	.....	6.50	1.11
Cost per cu. yd.	2.84		$.....		$14.63

If wheelbarrows are used instead of concrete buggies, add ¼-hr. labor time per cu. yd.

If small power buggies are used for transporting the concrete from mixer to place of deposit, deduct about ¼-hr. per cu. yd.

Using a two sack (11-S) mixer, concrete buggies, and based on 7½ cu. yds. an hr. the labor per cu. yd. of concrete should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	2.27	$.....	$.....	$5.00	$11.35
Hoisting engineer	.13	.....	.....	6.00	.78*
Mixer engineer	.13	.....	.....	6.00	.78
Mason or cement finisher	.13	.....	.....	6.50	.85
Cost per cu. yd.	2.66		$.....		$13.76

***Add only if required.**

If wheelbarrows are used instead of concrete buggies, add ¼-hr. labor time per cu. yd.

If small power buggies are used for transporting the concrete from mixer to place of deposit, deduct about ¼-hr. per cu. yd.

Mixing and Placing Concrete on Jobs Using a Bucket Hoist and a 16-S Mixer.—A 16-S mixer will discharge about 16 cu. ft. of mixed concrete per batch.

The labor cost of mixing and placing the concrete will vary with the method used in supplying the mixer and in handling the concrete from the mixer to the floor, also the class of work, whether thick or thin slabs, etc.

Assuming the mixer is fed in the usual way and the concrete hoisted to the various floors in a concrete bucket and then wheeled in concrete buggies to place of deposit, the mixer should average 20 to 25 batches an hr. or 160 to 200 per 8-hr. day.

While many contractors attempt to turn out a batch every 1 to 1½ minutes, this is usually not possible. Most architects and engineers specify the concrete be mixed for 1½ to 2 minutes after all ingredients are in the mixer. Allowing for loading and unloading, 20 to 25 batches an hour is about average output.

Approximately the following crew will be required to operate the mixer to capacity:

	No. Men
Supplying mixer with stone or gravel	7
Supplying mixer with sand	4
Supplying mixer with cement	2
Feeding and dumping mixer	1
Attending hopper on floor and filling buggies	1
Wheeling concrete from hopper to place of deposit (concrete buggies)	4
Wheeling concrete from hopper to place of deposit (wheelbarrows)	8
Dumping barrows or buggies, spreading, grading, vibrating and tamping concrete	5
Building and moving runways, cleaning buggies and mixer, cleanup empty cement sacks, misc. labor	2

Based on 12½ to 15 cu. yds. an hr. the labor per cu. yd. should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	1.75	$.....	$.....	$5.00	$ 8.75
Mixer engineer	.07	.....	.....	6.00	.42
Hoisting engineer	.07	.....	.....	6.00	.42*
Mason or cement finisher	.07	.....	.....	6.50	.46
Cost per cu. yd.	1.96		$.....		$10.05

*Add only if required.

If power buggies are used for transporting the concrete from mixer to place of deposit, deduct ¼ to ⅓-hrs. per cu. yd.

If wheelbarrows are used instead of concrete buggies, add ¼-hr. labor time per cu. yd.

On small reinforced concrete jobs where the yardage is insufficient to warrant building a special concrete hoist and all concrete is hoisted in wheelbarrows or concrete buggies on an ordinary double cage material hoist, it will be impossible to obtain the same output from the mixer as where a bucket hoist is used. When these conditions prevail, figure the labor costs given under "Mixing and Placing Concrete on Small Jobs, Using a One Sack (6-S) Mixer and Wheelbarrows or Concrete Buggies."

Mixing and Placing Concrete for Thin Concrete Floors of Clay Tile, or Metal Pan and Joist Construction.—The labor

cost of placing concrete for floors of this type will run a trifle higher than for solid concrete floors. The concrete is usually only 2" to 2½" thick over the tile or "pans," which necessitates more labor spreading, grading and tamping and more labor building and removing runways, etc., than when placing a thick slab. Placing concrete in small joists, usually only 4" or 5" wide also requires time and care to see that all reinforcing steel is completely embedded and the bottoms on all joists filled with concrete to eliminate voids and honeycombing.

It ordinarily requires ¼ to ½-hr. additional labor time per cu. yd. for slabs 2½" and under in thickness.

Mixing and Placing Concrete for Thin Concrete Floors Placed over Steel Plate or Truss Joists and Metal Lath.—Floors of this type average only 2" to 3" thick and while it is a simple matter to place the concrete, there is a large area to cover to place a comparatively small amount of concrete. This requires extra labor spreading and grading concrete, placing and removing runways, etc. For floors of this type, add ¼ to ½-hr. additional labor time per cu. yd. of concrete for estimating purposes. For more accurate analysis of costs of metal lath centering see pages 440 through 443.

Fireproofing Structural Steel Columns and Beams with Concrete.—Buildings having structural steel frames often have the columns and beams fireproofed by covering them with 2" of concrete. This requires forms the same as ordinary concrete beams and columns and the cost is practically the same.

When fireproofing just the beams and columns with concrete, the labor cost will run rather high per cu. yd. as this is another instance of covering a large area to place a small amount of concrete. Use the same labor costs as given under "Mixing and Placing Concrete on Small Jobs, Using a One Sack (6-S) Mixer and Wheelbarrows or Concrete Buggies."

Mixing and Placing Concrete Using Spouting Systems.—Since the water-cement ratio of proportioning concrete aggregates has been adopted on most important work, spouting systems are rarely used today. Most specifications prohibit the use of long spouts for chuting concrete from the mixer to the forms on account of the great danger of segregation. Buggies or buckets are generally desirable. Self-propelled buggies which are fully described under "Concrete" are now available and are used on many of the larger jobs.

Mixing and Placing Concrete Using Conveyors and Batcher-bins for Supplying 28-S Mixer.—This system of mixing concrete

can be used to advantage only on large jobs containing several thousand cubic yards of concrete, on account of the large initial expenditure required for bins, batchers, conveyors, etc. Prices are given under "Tools and Equipment."

Where this method of supplying the mixer is used, conveyors are used for conveying the sand and gravel to elevated bins, where it is fed to the mixer. This eliminates all labor on sand and gravel except two or three men to operate conveyors.

To obtain a basic labor cost, assume the concrete is also wheeled in buggies from hoisting tower to place of deposit.

Based on an average of 20 to 25 batches an hr. or 160 to 200 per 8-hr. day, the labor cost of mixing and placing one cu. yd. of concrete should run as follows:

	Hours	Rate	Total	Rate	Total
Labor	0.90	$.....	$.....	$5.00	$4.50
Mixer engineer	.05	.....	.....	6.00	.30
Hoisting engineer	.05	.....	.....	6.00	.30*
Mason or cement finisher	.05	.....	.....	6.50	.33
Cost per cu. yd.	1.05		$.....		$5.43

*Add only if required.

Remember to add plant and equipment labor costs to above.

If power buggies are used for transporting the concrete from mixer or hopper to place of deposit, deduct ¼ to ⅓-hrs. per cu. yd.

If concrete is wheeled in barrows from floor hopper to place of deposit, add ¼-hr. labor time per cu. yd.

If the above method is used for placing concrete for floors 2" and under in thickness, add ½-hr. additional labor time per cu. yd. to cover spreading, grading and tamping thin concrete floor slabs.

Mixing and Placing Concrete Where Materials Are Delivered to Job Batch Proportioned.—Another method of mixing and placing reinforced concrete is to have the concrete aggregates delivered to the job in trucks, correctly proportioned for one batch of concrete, including cement, sand and gravel or crushed stone.

When this method is used, the concrete aggregates for each batch are proportioned in the material yard and delivered to the job ready to mix. The truck backs up to the mixer and discharges the cement, sand and gravel or crushed stone into the loading hopper. A paving mixer with a large, flat loading hopper

is often used for this purpose as it facilitates dumping the aggregates from the trucks into the loading hopper.

This method eliminates the necessity of all men loading and wheeling cement, sand and coarse aggregates, and the time required per cu. yd. of concrete should average as given in the following table:

Labor Mixing and Placing One Cu. Yd. of Reinforced Concrete When Aggregates Are Yard Proportioned and Delivered to a 28-S Mixer in Batch Trucks

Method of Mixing and Placing Concrete	Hours per Cubic Yard			
	Common Labor	Mixer Engr.	Hoist Engr.	Foreman
Hoisting concrete in wheelbarrows on a material hoist and wheeling into place	2.6	.13*	.13*	.13*
Hoisting concrete in concrete buggies on a material hoist and wheeling into place	1.3	.09*	.09*	.09*
Thin floors 2 to 2½-in. thick. Hoisting concrete in concrete buggies on a material hoist and wheeling into place	1.8	.09*	.09*	.09*
Hoisting concrete in a concrete bucket, discharging into a floor hopper and wheeling into place, using wheelbarrows	1.1	.05*	.05*	.05*
Hoisting concrete in a concrete bucket, discharging into a floor hopper and wheeling into place, using concrete buggies	0.8	.05*	.05*	.05*
If power buggies are used for transporting concrete from hopper to place of deposit, deduct per cu. yd. of concrete	0.25-0.33	...	...	...
Hoisting concrete in a concrete bucket, using a crane hoist, and depositing concrete on floor or into forms without wheeling	0.6	.05*	.05*	.05*
Add for crane and operator	...	...	.05*	...
For thin floors, 2 to 2½-in. thick, add to the above costs	0.5	...	...	...

*See top of page 453.

Placing Concrete Using a Crane and Bucket.

*Time of mixer engineer, hoisting engineer and foreman will vary according to number of cubic yards of concrete placed per day. (Refer to table on page 450.)

The above costs do not include cost of erecting and dismantling material hoists, concrete hoisting towers, concrete mixer, hoisting engines, etc., which may run from $500.00 to $5,000.00, depending upon size of job and type of equipment used.

Also, add cost or rental of crane hoist where this method is used.

Ready Mixed Concrete

When using ready-mixed concrete on all classes of reinforced construction, such as floors, beams, girders, columns, etc., the cost of handling and placing the concrete will run approximately the same as for job mixed concrete, except for the labor handling materials, supplying and operating mixer, etc., as the trucks dump the ready-mixed concrete into a receiving hopper or bucket, where it is distributed by wheelbarrows, concrete buggies or hoisted into place.

In addition to saving about ¾-hr. labor time per cu. yd. of concrete for charging mixer, the use of ready-mixed concrete saves the cost of cement sheds and provides more room for storing other materials. It permits higher output per hour because ready-mixed concrete can usually be furnished in any quantities desired and it also saves the cost of installing and dismantling expensive equipment, which may easily cost $5,000.00 or more on a job of any magnitude.

It is necessary to have a fairly large size hopper on the job to receive the concrete from the trucks, as this hopper must be of sufficient capacity to supply the hoisting bucket as fast as it can handle the concrete, otherwise the work will be slowed down and with the crew idle part of the time the labor costs go up.

The labor cost of handling and placing ready-mixed concrete will vary with the amount handled and placed per day, the method of handling, hoisting and placing the concrete and the class of work, as it will cost less to place concrete in heavy floors than in thin floor slabs 2 to 2½-in. thick.

The following table gives the labor hours necessary to handle and place one cu. yd. of ready-mixed concrete, using various methods:

Labor Placing One Cu. Yd. of Ready-Mixed Concrete for Reinforced Floors, Beams, Girders, Columns, Etc.

Method of Handling and Placing the Concrete	Hours per Cubic Yard: Common Labor	Hoisting Engineer	Foreman
Hoisting concrete in wheelbarrows on a material hoist and wheeling into place.	2.3	.11*	.11*
Hoisting concrete in concrete buggies on a material hoist and wheeling into place	1.1	.08*	.08*
Thin floors 2 to 2½-in. thick. Hoisting concrete in wheelbarrows on a material hoist and wheeling into place.....	2.8	.11*	.11*
Thin floors 2 to 2½-in. thick. Hoisting concrete in concrete buggies on a material hoist and wheeling into place....	1.6	.08*	.08*
Hoisting concrete in a concrete bucket, discharging into a floor hopper and wheeling into place, using wheelbarrows	1.2	.05*	.05*
Hoisting concrete in a concrete bucket, discharging into a floor hopper and wheeling into place, using concrete buggies	0.8	.04*	.04*
If power buggies are used for transporting concrete from hopper to place of deposit, deduct per cu. yd.....	0.25-0.33	...	...
Mobile crane with bucket on ground, hoisting concrete to floor or forms and depositing directly into forms.....	0.5	...	.04*
Add for rental of mobile crane and operator	...	.04*	...
For thin concrete floors, 2 to 2½-in. thick, add to the above costs.....	0.5	...	...

*Time of hoisting engineer and foreman will vary acording to the number of cubic yards of concrete placed per day.

The above costs do not include cost of erecting and dismantling material hoists, concrete hoisting towers, etc., which may run from $500.00 to $5,000.00, depending on size of job and type of equipment used.

Pumpcrete* or Placing Concrete by Pipeline

The development and perfection of a pump for transporting freshly mixed concrete through pipelines has revolutionized the placing of substantial yardages of concrete in dams, tunnels, re-

Paving Mixer Charging Model 200 D "Pumpcrete"

taining walls, bridge decks, mill, factory, warehouse and apartment buildings where concrete is required at rates varying from 15 to 65 cu. yds. an hr. This machine for pumping concrete is called a "Pumpcrete" and pumps concrete through a pipeline in much the same manner that a piston pump pumps water. It will transport freshly mixed workable concrete to distances of 1,000 ft. and to heights in excess of 120 ft. Many instances are known where the Pumpcrete has delivered the concrete to the forms 2,000 ft. away, or 140'-0" high where a well designed mix is used.

The Pumpcrete will handle efficiently concrete of any slump from ½" to 7" but the most dependable slump for general con-

*Rex Chainbelt, Inc. Milwaukee, Wis.

ditions is around 2" to 4". However, plastic concrete of around 6" slump can generally be pumped the maximum distance and height. The rate of pumping depends considerably upon the consistency of concrete.

The concrete is delivered to the forms in better condition than when discharged from the mixer due to the added mixing received in the remixing hopper which receives the concrete from the mixer and keeps it in a uniform condition as it is fed through the cylinder of the Pumpcrete to the pipeline. During the pumping operation, the pipeline is full at all times which keeps the concrete from segregating, thereby eliminating one of the major objections found in most methods used to transport concrete to the forms. The troweling action of the walls of the pipeline in contact with the concrete as it passes through improves the quality of the concrete.

The smooth, even flow of concrete into the forms reduces the stresses in the bracing and ties. Danger of "honeycomb" is reduced as there is no "slug" of pebbles dumped in, as in the case of a buggy, at the end of a batch which might not be properly spaded. Walls 120 ft. long and 15 ft. high have been made at one pour in 3 ft. lifts without signs of longitudinal jointing or uneven surfaces due to the dumping of wheelbarrows or buggies in such a way as to splash the form above the point of placement.

Runways for wheelbarrows or concrete buggies are not required when placing concrete by pipeline, although it is necessary to provide supports for the pipelines, which usually consists of "horses" or "trestles," similar to those shown in the illustration on the following pages.

Concrete can be placed with the Pumpcrete in 2" sections, thin walls, footings or in large masses.

Cost of Pumpcrete* Equipment.—Pumpcrete equipment is manufactured in two different sizes, with three different capacities, to meet the requirements of most any size job, as follows, f.o.b., Milwaukee:

Model 160 single Pumpcrete, rated capacity 15 to 20 cu. yds. per hr.

Price, with gasoline power, mounted on 4 pneumatic tired wheels, complete with conical remixing hopper (1¼ cu. yd. capacity) and auxiliary equipment for Model 40 (6-⅝" OD) pipe $12,620.00

Model 200 Single Pumpcrete, rated capacity 25 to 33 cu. yds. per hr.

*Rex Chainbelt, Inc. Milwaukee, Wis.

Price, equipped with gasoline engine, mounted on skids, complete with pugmill remixer (2 cu. yd. capacity) and auxiliary equipment for Model 80 (8-⅝" OD) pipeline $19,680.00

Model 200 Double Pumpcrete, rated capacity 50 to 65 cu. yds. per hr. Pugmill remixer capacity may be increased to suit job conditions. Price, equipped with gasoline power, mounted on skids, complete with pugmill remixer (3 cu. yd. capacity) and auxiliary equipment for Model 80 (8-⅝" OD) pipeline.....$33,300.00

Price of pipeline and fittings complete with quick-acting toggle couplings, cost as follows:

For 160 Model Only

Kind	Length	Model	Size "OD"	Weight	Price Each
Straight	10'-0"	40	6⅝"	158#	$ 70.00
Straight	5'-0"	40	6⅝"	102#	54.00
Straight	3'-0"	40	6⅝"	79#	49.00
Straight	2'-0"	40	6⅝"	68#	44.00
Straight	1'-0"	40	6⅝"	59#	43.00
90° Ell	10'-0"	40	6⅝"	158#	146.00
45° Ell	5'-0"	40	6⅝"	102#	97.00
22½° Ell	2'-0"	40	6⅝"	68#	81.00
11¼° Ell	2'-0"	40	6⅝"	67#	65.00

For 200 Models—Single and Double

Kind	Length	Model	Size "OD"	Weight	Price Each
Straight	10'-0"	80	8⅝"	235#	$101.00
Straight	5'-0"	80	8⅝"	152#	77.00
Straight	3'-0"	80	8⅝"	120#	70.00
Straight	2'-0"	80	8⅝"	103#	66.00
Straight	1'-0"	80	8⅝"	90#	64.00
90° Ell	10'-0"	80	8⅝"	235#	193.00
45° Ell	5'-0"	80	8⅝"	152#	135.00
22½° Ell	2'-0"	80	8⅝"	103#	111.00
11¼° Ell	2'-0"	80	8⅝"	102#	92.00

Makeup of a Pumpcrete* Plant.—The fixed charges on a Pumpcrete plant will vary with each size machine as the amount of pipeline, pipeline fittings, distributing devices, etc. vary with the job conditions.

The following table gives the rated capacity and approximate cost of a Pumpcrete plant:

Pumpcrete Model	160S	200S	200D
Rated Capacity Cu. Yds. per Hr.	15-20	25-33	50-65
Average Plant Cost, 530' Pipe (Change to Suit)	$17,770	$26,950	$40,595

*Rex Chainbelt, Inc. Milwaukee, Wis.

Estimated Life in Cu. Yds.	100,000	125,000	250,000
Depreciation per Cu. Yd. (Capital Investment Only)	$0.178	$0.215	$0.163

On large projects many contractors establish an approximate salvage value for most of their equipment and make a complete write-off for each job. In this event, 50% is a fair estimate on most jobs.

The above depreciation charges do not include interest on investments, repairs, replacements, insurance or taxes.

The cost of an average Pumpcrete plant using a 160 Single Pumpcrete should run as follows, f.o.b. Milwaukee:

160 Single Pumpcrete, gasoline engine, mounted on four pneumatic tired wheels, complete with cone hopper remixer and auxiliary equipment for washing out Model 40 pipeline	$12,620.00
50—10′ straight sections of Model 40 pipe (6⅝″ OD) at $70.00 each	3,500.00
4—5′ straight sections of Model 40 pipe (6⅝″ OD) at $54.00 each	216.00
2—3′ straight sections of Model 40 pipe (6⅝″ OD) at $49.00 each	98.00
2—2′ straight sections of Model 40 pipe (6⅝″ OD) at $44.00 each	88.00
1—1′ straight section of Model 40 pipe (6⅝″ OD) at $43.00 each	43.00
2—90° Elbows at $146.00 each	292.00
4—45° Elbows at $97.00 each	388.00
2—22½° Elbows at $81.00 each	162.00
2—11¼° Elbows at $65.00 each	130.00
1—Distributing Spout complete with Extension and Hanger	214.00
Total Cost	$17,751.00

Freight factory to destination varies.

Additional pipe may be required and is available at the above prices.

Five-inch pipeline gates and dent remover (for removing dents from dented pipe) are available.

Operating costs consist of power (gas or electric), oil, grease, valve compound, mechanical maintenance and replacement of the pump's wearing parts.

Power, oil and grease should run from 8 to 10 cents per cu. yd., depending upon operation and locality, vertical and horizontal distances, etc.

Mechanical maintenance will vary with the efficiency of the operator, the type of work, abrasiveness of materials, etc., as with all construction machinery.

In addition to replacements for the machine there will be pipeline maintenance which will be dependent upon the abrasiveness of materials. The couplings, which represent approximately three-fourths of the cost of pipe sections, will last indefinitely. The straight pipe will last from 50,000 to 150,000 cu. yds. and the elbows will last from 30,000 to 70,000 cu. yds., depending upon the abrasiveness of the concrete.

The piping can be replaced as it becomes worn out and the old couplings reused.

Cost of Pipeline Handling.—Many variables obviate the possibilities of setting definite man-hour costs per cu. yd. even for simple pipeline installations. On small jobs, many contractors do not segregate this item from other incidental labor as it is handled by the regular puddling crew. On wide area structures, where daily pourings in scattered locations are the rule, it is customary to have a separate pipe gang of 3 or 4 men, depending on the size of pipe.

The following data, based on field experience, is given merely as an aid in probable cost for some phase of pipe handling operations, as conditions vary widely on different jobs.

Two men can readily carry and handle a 10-ft. length of Model 40 pipe (6⅝" OD 168 lbs).

Four men can readily carry and handle a 10-ft. length of Model 80 pipe (8⅝" OD 235 lbs).

The rate at which pipeline can be set up and coupled is approximately the same for both Model 40 and Model 80 pipe, if the ratio of men respectively is maintained. However, the rate at which a given crew will lay and couple pipe will vary considerably with the distance they must carry, the kind of footing they must carry over, the nature of the pipe supports, and the caliber of the men.

Taking these factors into consideration, approximate figures for straight pipe handling at moderate carrying distances are given below:

Conditions	Lin. Ft. per Hour
Level footing, laying pipe on ground	150
Level footing, mounting pipe on shoulder-high supports	100
Rough ground, bad footing, difficult pipe supports as in wall pours	75

The above quantities based on a 3-man gang for Model 40 pipe and a 4-man gang for Model 80 pipe.

Pipeline Data.—The maximum distance recommended for ordinary pumping conditions and the maximum size coarse aggregate that can be handled satisfactorily with the two sizes of Pumpcrete is shown below:

Model	Pipe Model & Size	Coarse Aggregate	Horizontal Distance*	Vertical Distance†
160S	40-6⅝" OD	2" 100% passing	1,000 ft.	120 ft.
200D	80-8⅝" OD	3" 100% passing	1,000 ft.	120 ft.
200S	80-8⅝" OD	3" 100% passing	800 ft.	100 ft.

*A 90° Elbow is figured as equivalent to 40 ft. of horizontal piping. A 45° Elbow is equivalent to 20 ft., and a 15° Elbow is equivalent to 10 ft.

†Not over 200 ft. of pipe actually. A combination of horizontal and vertical distances is to be calculated on the basis of 1 ft. of vertical equalling 8 ft. of horizontal pumping. The total equivalent distance should not exceed the equivalent horizontal pumping distances shown in the tabulation.

Assume the project is equipped with a Model 200 Single Pumpcrete pumping through 8-⅝" OD pipeline. The actual length of pipeline is 360 ft., which is made up of the following sections: 320 ft. straight pipe; 2 - 90° Elbows and 4 - 45° Elbows. There is a vertical lift at the end of the pipeline of 40 ft.

The equivalent length of straight horizontal pipe is determined as follows:

320 ft. straight pipe.....Equals	320 ft.
2 - 90° Elbows (equiv. to 40 ft. straight pipe).....	80 ft.
4 - 45° Elbows (equiv. to 20 ft. straight pipe).....	80 ft.
40 ft. vertical lift (equiv. to 1 ft. vert.=8 ft. horiz.).....	320 ft.
	800 ft.

Cost of Placing Concrete by Pipeline.—The cost of placing concrete by pipeline varies widely as do other methods of distribution, and is governed by the size of the job, area covered, the yardage of concrete that can be placed at one setup of the pipelines, whether thick or thin walls, slabs or large masses of concrete are being placed.

When placing concrete by ordinary methods, the cost of rental, erecting and dismantling the hoisting tower and spouts must be considered, also the cost of raising the concrete hopper and moving spouts for placing the concrete.

When buggies are used for distributing the concrete, the cost of the hoist must be considered, moving and raising concrete hoppers, building, placing and removing concrete buggy runways, cost of buggies, labor, etc.

The same conditions must be considered with Pumpcrete distribution, which includes original cost of equipment, depreciation or salvage value, cost of setting up and removing Pumpcrete, pipelines, etc.

Always bear in mind, the cost of mixing the concrete will be the same regardless of the method of distribution because where the concrete is mixed and dumped into a hoisting bucket using ordinary methods, it is deposited in the Pumpcrete hopper under the Pumpcrete method. It is only the method of handling, hoisting and placing the mixed concrete that should be considered. This also applies where ready-mixed concrete is used.

The crew operating the Pumpcrete unit will vary with the size, area and yardage in the job. An operator is required on the Pumpcrete, a foreman and 6 to 12 laborers should place and remove pipelines, handle, spread and level the concrete, and the quantity will vary from 15 to 65 cu. yds. an hr. depending upon the size of the Pumpcrete and the class of work.

The size of the crew varies with the equipment used and the class of work. The actual costs on the following pages give the actual time required for each class of labor which will enable the estimator to determine the most economical methods of mixing, handling and placing the concrete.

Cost of Placing Concrete on a Commercial Building.—On a 5-story steel frame commercial building, 140 by 250 ft. having floors of metal pan construction, with pans from 6″ to 14″ deep and 2½″ of concrete over the pans, the entire job contained approximately 5,200 cu. yds. of concrete.

The concrete was ready-mixed, using ¾″ gravel aggregate and having a 5″ to 6″ slump.

The concrete was delivered to the job and deposited direct into the remixing hopper on the Pumpcrete and pumped to the various floors.

The labor per cu. yd. cost as follows:

	Hours	Rate	Total	Rate	Total
Pumpcrete operator	0.07	$.....	$.....	$6.50	$0.46
Pumpcrete hopper man	.07	.....	.....	5.20	.36
Labor puddling, vibrating, pipeline, etc.	.45	.....	.....	5.00	2.25
Foreman	.07	.....	.....	5.25	.37
Cost per cu. yd.	.66		$.....		$3.44

Average rate of pour 15.1 cu. yds. per hr. Maximum rate of pour 19 cu. yds. per hr.

The above costs do not include cost of Pumpcrete, depreciation, parts and replacements, gas and oil, labor installing and removing equipment, etc.

Placing Concrete by Pipeline on a Sewage Disposal Plant.—On a sewage disposal plant, size 370'-0"x380'-0", containing 15,000 cu. yds. of concrete consisting of heavily reinforced concrete in slabs and thin walls, all concrete was placed by pipeline.

The concrete plant was placed midway of one side where a railroad spur provided for delivery of cement in cars, which eliminated a second handling. The sand and gravel was dumped directly into the charging hopper of concrete mixer by "batching" trucks, which eliminated all handling of aggregates on the job except one man dumping trucks. The mixer discharged into the remixing hopper of a single Pumpcrete which was placed below grade in the excavation made for the plant addition. From this point the concrete was pumped through 8" pipelines to the point of placement.

The floors of the aerating basins, 30 ft. wide and 120 ft. long were poured by radial spouting from the end of the pipeline, which was supported on horses. The line was taken up as the concreting progressed and laid in the next basin.

Staging, as illustrated, supported on the forms permitted erection of the pipeline, pouring 112 cu. yds. of concrete in the wall and removal of the pipe line and forms in one day. The walls of the aerating and settling basins were 15 ft. high and were poured in 3 ft. lifts. Valves at 20 ft. intervals were inserted in the 120 ft. of distributing line which permitted the withdrawal of concrete at these points. Elephant trunks directed the concrete into specially constructed chutes that led the concrete down through the maze of steel to the level being poured where it was discharged without spattering the forms above that point. Pouring was started from the valve nearest the Pumpcrete. When enough concrete had been withdrawn at a valve, it was closed and the next valve opened for concreting at this point. This procedure was continued until the lift was completed at the end of the pipeline.

With the aid of internal vibration, these high long walls were poured without blemishes or jointing.

The average labor cost of mixing and placing one cu. yd. of concrete was as follows:

Placing Concrete by Pumpcrete Showing Pipeline Supported on Horses

	Hours	Rate	Total	Rate	Total
Mixing Concrete					
1 man dumping trucks	0.053	$.....	$.....	$5.00	$0.27
2 men handling cement	.10	.....	.....	5.00	.50
1 man operating mixer	.071	.....	.....	6.00	.43
Placing Concrete by Pipeline					
1 Pumpcrete operator	.071	.....	.....	6.50	.46
1 foreman	.071	.....	.....	5.25	.37
3 laborers*	.86	.....	.....	5.00	4.30
Cost per cu. yd.	1.226		$.....		$6.33

*Labor on Pumpcrete includes time placing and removing pipeline.

During the pouring of the concrete in the walls, 3 additional men were required operating vibrators. Vibrators would be required regardless of the distribution method used.

Placing Concrete by Pipeline on a Pumping Station.—A large pumping station requiring 35,000 cu. yds. of concrete consisting of both walls and floors.

Concrete was placed at the rate of 25 to 60 cu. yds. per hr. depending upon the type of pour. The average was lowered considerably by the use of forms that could not be filled rapidly,

necessitating the pump operating at ½ normal capacity on most wall pours.

Concrete proportions were 1:2.9:3.7 by weight, with 2" gravel as coarse aggregate and the average slump was about 4".

The concrete was wet batched a distance of one mile in flat bottom trucks from a central mixing plant in the material yard. This method proved satisfactory due to the reconditioning efficiency of the pugmill Remixer and no pumping difficulty was encountered.

The mixing plant consisted of 2—28S mixers; a 30 cu. yd. aggregate bin with weigh-batchers; a 700 bbl. cement silo; a 5" cement blower and a 2-ton crane with a 55-ft. boom and a 1½ cu. yd. bucket. Bulk cement was pumped 200 ft. from box cars on a siding.

Placing Concrete with Pumpcrete Equipment on Wide Area Floor Slab

Seven dump trucks were required for maximum production of 60 cu. yds. an hr. and scaled down proportionately as the yardage decreased.

A Model 200 double Pumpcrete with 8" pipeline was used and the maximum distance pumped was 650 ft. with a 25 ft. riser.

The average labor cost based on 32 cu. yds. per hr. was as follows:

Batcher Plant Mixing Crew	Hours	Rate	Total	Rate	Total
Crane operator	1.1	$.....	$.....	$6.75	$ 7.43
Mixer operator	1.1	.....	.....	6.00	6.60
Batcher man (also handled cement blower)...	1.1	.....	.....	5.10	5.61
Carried forward	3.3	.....	$.....		$19.64

Butcher Plant Mixing Crew	Hours	Rate	Total	Rate	Total
Brought forward	3.3	$.....	$.....	$.....	$19.64
Labor for cleanup, etc....	1.1	.....	.....	5.00	5.50
Truck drivers (average).	5.5	.....	.....	4.90	26.95
Foreman	1.1	.....	.....	5.25	5.78
Pumpcrete					
Pumpcrete operator	1.1	.....	.....	6.50	7.15
Oiler	1.1	.....	.....	5.00	5.50
Labor dumping and cleaning trucks	1.1	.....	.....	5.00	5.50
Distributing and Placing					
Concrete labor, puddlers, etc.	12.5	.....	.....	5.00	62.50
Foreman	2.5	.....	.....	5.25	13.13
Cement mason	1.1	.....	.....	6.50	7.15
Cement mason helper....	1.1	.....	.....	5.00	5.50
Labor cost 32 cu. yds...	31.5		$.....		$164.30
Labor cost per cu. yd.....	1		.....		5.13

The above includes all lost time and also includes .20 hr. per cu. yd. for distributing crew for handling and placing pipe lines, scaffolding, etc.

To the above costs it will be necessary to add for rental of crane, motor trucks, mixers and other equipment costs, fuel, insurance, taxes, etc.

Wearing parts on Pumpcrete averaged about 10 cts. per cu. yd. on the 35,000 cu. yds. placed.

A Reinforced Concrete Reservoir Placed by Pipeline.—A large reinforced concrete reservoir containing 5,800 cu. yds. of concrete was placed using a No. 160 Pumpcrete with a Model 40 pipeline (6⅝" O.D.).

There were approximately 1,030 cu. yds. in the footings; 380 cu. yds. in walls 6'-0" high and 15" to 18" thick; 816 cu. yds. in columns which were 2'-0" in diam. and 12'-0" to 32'-0" high, while the floor slabs varied from 8" to 12" thick and contained 3,600 cu. yds. of concrete.

This concrete was pumped a distance of from 50 to 700 ft., sometimes the pipe was supported by shoulder high horses and at other times it was laid directly on the ground.

The mixing plant consisted of a paving mixer charged from one truck from a 20 cu. yd. road bin set at stock pile some 50 ft. distant. The average rate of pouring varied from 14 to 17 cu. yds. per hr. depending upon the class of work.

Concrete Placed 172 Feet above Mixer by Pumpcrete

Placing Concrete in Circular Tank Walls Using Swivel Pipe Joint

A crew of 14 men mixed and placed 16 cu. yds. per hr. at the following labor costs:

Plant Crew Mixing Concrete	Hours	Rate	Total	Rate	Total
Crane operator loading road bin	1.1	$.....	$.....	$6.75	$ 7.43
Batcher man	1.1	.....	.....	5.10	5.61
Truck driver	1.1	.....	.....	4.90	5.39
Cement dumper	2.2	.....	.....	5.00	11.00
Mixer operator	1.1	.....	.....	6.00	6.60
Pumpcrete operator	1.1	.....	.....	6.50	7.15
Distributing and Placing Crew					
Concrete labor (puddlers)	5.4	.....	.....	5.00	27.00
Foreman	1.2	.....	.....	5.25	6.30
Carried forward	14.3	.....	$.....		$76.48

	Hours	Rate	Total	Rate	Total
Pumpcrete Crew					
Brought forward	14.3	.....	$.....		$76.48
Cement mason	1.1	.....	.....	$6.50	7.15
Cement mason helper....	1.1	.....	.....	5.00	5.50
Labor cost 16 cu. yds...	16.5		$.....		$89.13
Labor cost per cu. yd....	1.03		.....		5.57

The distributing crew handled and placed all pipe line, scaffolding, etc., which amounted to .06 hrs. per cu. yd. and is included in the above costs.

To the above costs it will be necessary to add for rental of crane, motor trucks and other equipment costs, also fuel, insurance, taxes, etc.

Placing Bridge Footings and Piers by Pipeline.—On a bridge 1,739 ft. long with the piers 107 ft. above the mixer, a No. 160 Pumpcrete was used to place 3,000 cu. yds. of concrete in the footings and piers.

The maximum distance pumped was 520 ft. horizontally and 107 ft. vertically with one 90 degree elbow. 2 forty-five degree elbows; three 30 degree and one 15 degree ell in the line. This is equivalent to over 1,400 ft. of horizontal straight pipe. The average placing rate was 17 cu. yds. per hr. although a maximum rate of 22 cu. yds. per hr. was attained at times.

The plant consisted of a 14S mixer with a wide skip, set

Placing Concrete on Hangar Roof Using Pumpcrete Equipment

directly over the Pumpcrete hopper and charged by batch trucks hauling ½-mi. from batcher bins located on a siding. Bins were loaded by crane and bucket.

The distributing procedure was to run the pipe straight up the center of the form tower, high enough to deflect the stream of concrete to either side alternately.

The following is the total crew required for placing concrete at an average rate of 17 cu. yds. per hr.:

Batcher Plant	Hours	Rate	Total	Rate	Total
Crane operator	1.1	$.....	$.....	$6.75	$ 7.43
Oiler and scale man	1.1	.....	.....	5.25	5.78
Labor	1.1	.....	.....	5.00	5.50
Truck drivers	2.2	.....	.....	4.90	10.78
Mixing and Pumping					
Mixer operator	1.1	.....	.....	6.00	6.60
Pumpcrete operator	1.1	.....	.....	6.50	7.15
Labor dumping trucks and cement	2.2	.....	.....	5.00	11.00
Foreman	1.1	.....	.....	5.25	5.78
Distributing and Placing					
Carpenter watching forms	1.1	.....	.....	6.75	7.43
Labor puddling, vibrators, etc.	6.6	.....	.....	5.00	33.00
Foreman	1.1	.....	.....	5.25	5.78
Labor cost 17 cu. yds.	19.8		$.....		$106.23
Labor cost per cu. yd.	1.17		.....		6.25

The distributing crew handled and placed all pipeline, scaffolding, etc., and is included in the above costs.

To the above costs it will be necessary to add for rental of crane, motor trucks, mixer, Pumpcrete and other equipment costs, also fuel, insurance, taxes, etc.

Placing Concrete by Pipeline on a Concrete Subway.—The concrete for a large concrete subway was mixed in a paving mixer on the street above the subway, dropped through a trough concrete lock to a No. 200 single Pumpcrete in the tunnel, where the concrete was pumped as high as 1,000 ft. in addition to a 180 degree gooseneck into the arch forms.

The aggregate was dry batched in trucks to the mixer, so there was no handling of materials. The maximum pumping rate was 33 cu. yds. an hr. and the average for the job was 25 cu. yds. an hr.

The total labor cost of mixing, pumping, placing, moving and

Two Model 160S Pumpcretes Connected to One Pipeline

Placing Concrete for Bridge Deck by Pumpcrete

placing pipelines, maintenance, etc., averaged as follows per cu. yd. of concrete:

Batcher Plant Mixing Crew	Hours	Rate	Total	Rate	Total
Foreman	0.07	$.....	$.....	$5.25	$0.37
Mixer operator	.05	.....	.....	6.00	.30
Labor dumping trucks	.07	.....	.....	5.00	.35
Concrete lock tender	.07	.....	.....	5.00	.35
Pumpcrete					
Pumpcrete operator	.06	.....	.....	6.50	.39
Concrete lock tender	.07	.....	.....	5.00	.35
Mixing and Placing					
Foreman	.07	.....	.....	5.25	.37
Cement mason	.025	.....	.....	6.50	.16
Concrete labor (7)	.40	.....	.....	5.00	2.00
Maintenance					
Electricians, compressor operators, etc.		.....	.....	.06	.60
Direct cost per cu. yd.	.885		$.....		$5.24
Misc. labor, lost time, 15%	.135		.....		.71
Labor cost per cu. yd.	1.02		$.....		$5.95

ARCHITECTURAL CONCRETE

Appearance is of paramount importance to the success of architectural concrete, therefore, every operation in the construction must be planned and executed with this in mind. The architect may design and specify but regardless of how detailed the specifications, it is the contractor and his superintendent who must have the know-how to detail and construct the forms and be on constant watch during all operations to see that the correct procedures are followed.

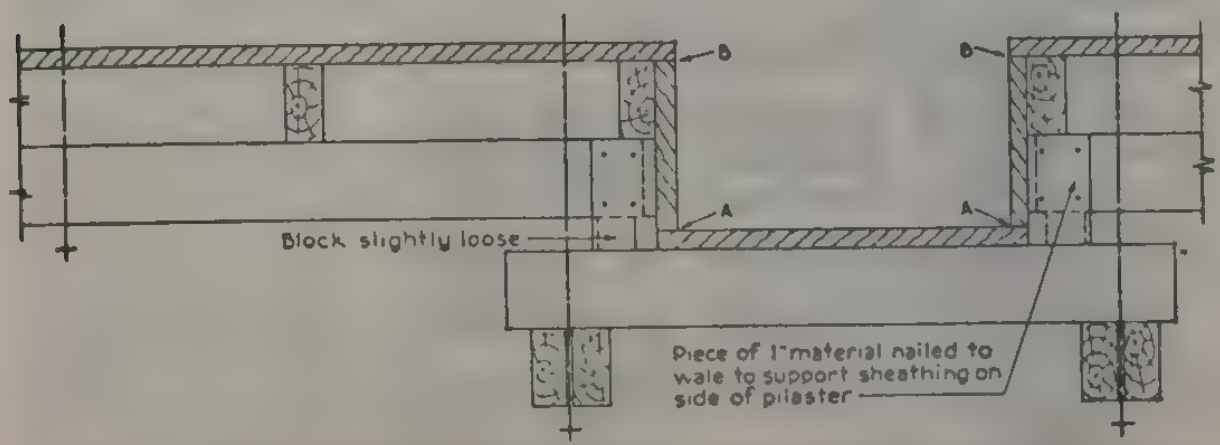
Forms for Architectural Concrete

Form design and construction must be approached with a different viewpoint from that for ordinary structural concrete. In structural concrete some leakage and irregularities in formwork may be tolerated, so long as the forms are strong enough to carry the weight of the concrete and the imposed loads and are built fairly true to line and grade. In architectural concrete, there must be no leakage through the forms and bulging and other irregularities must be so inconsequential as not to detract from the appearance of the finished surfaces.

Every conceivable precaution must be taken to prevent leakage through the forms. Chamfer strips at corners and edges are helpful for this purpose. Wherever possible, the forms should be designed so that pressure of the fresh concrete will tighten joints rather than tend to loosen them.

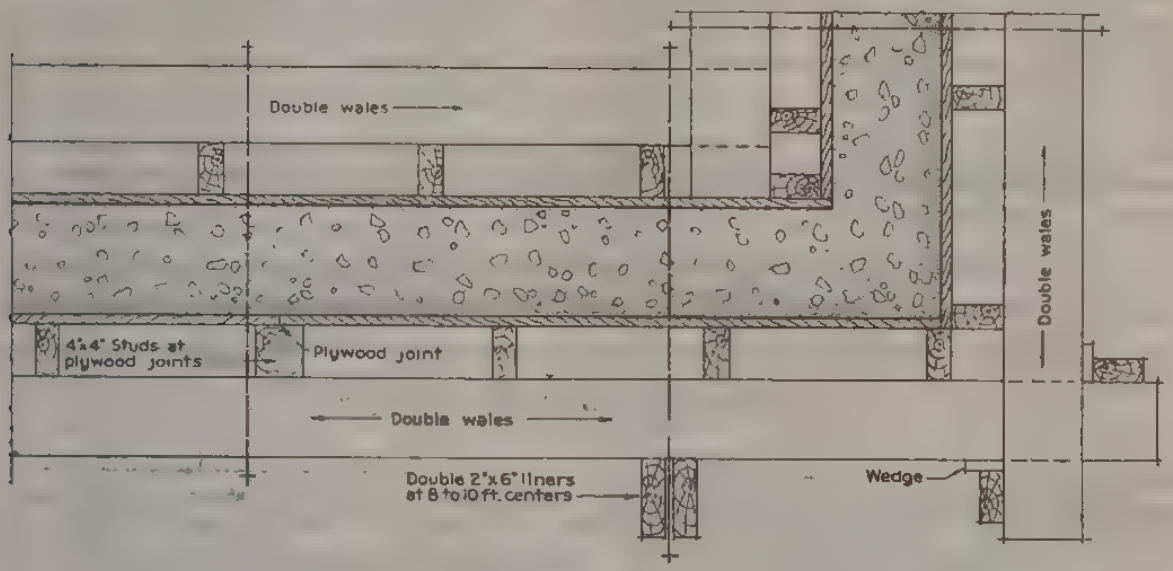
A common source of trouble is bulging of forms at external corners, resulting in both poor alignment and leakage with subsequent ragged corners, sometimes to the extent of exposing the aggregate at the corners.

The accompanying illustration gives one method of constructing the forms to provide locking of the corner. The wales are extended beyond the intersection far enough to permit two



Form Designed so that Pressure of Fresh Concrete Tightens It To Prevent Leakage.

vertical strips to be nailed in the corners. Wedges are driven between these strips and the wales to tighten the corner.

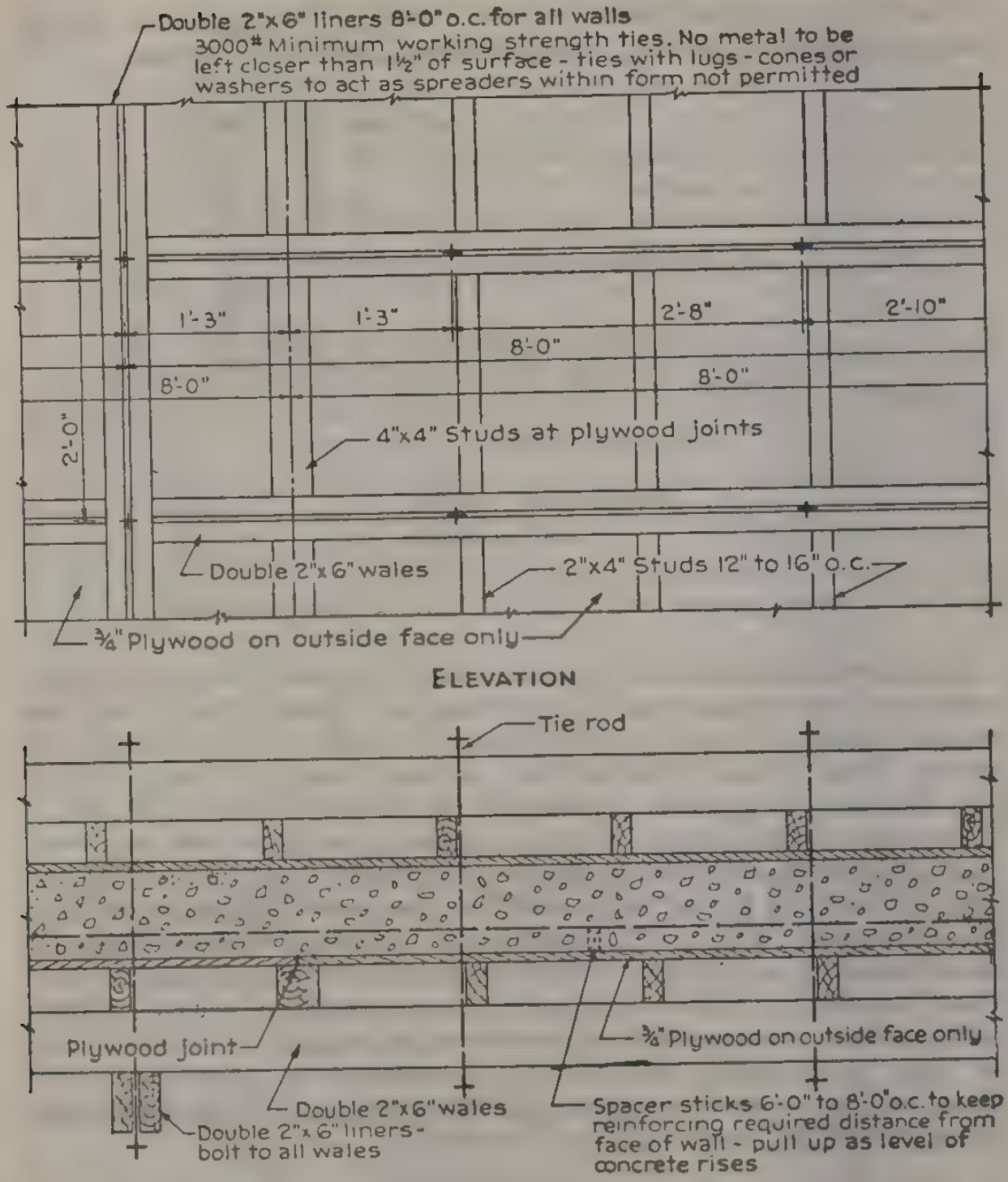


Form Construction To Provide Positive Corner Locking

Another method of locking the form corners is to use a tie instead of the wood strips and wedges. Since there are no wedges to work loose, a set of wales can be set and tightened on one level around the building without much chance of subsequent loosening when tightening the wales above or below.

Various materials are used for forming architectural concrete to eliminate imperfections and irregularities in the finished surface. Committee 622 of the American Concrete Institute has prepared a report entitled "Formwork for Concrete" which discusses these forming materials and their application. Plastic coated plywood, hardboard form lining, fiber or laminated pressed paper tubes, plaster waste molds, metal forms, fiber glass forms, etc. are all used as forming material for architectural concrete. Fiber glass has been used on large building projects with the forms being reused as many as 60 or 70 times.

Plywood Form Sheathing.—Smooth surfaces required on much present day work is obtained with plywood form sheathing. This should be of structural grade made especially for form use and preferably should be oiled at the factory. If oiled on the job, sufficient time should be allowed for the oil to penetrate and any surplus oil should be wiped off before the plywood is used. Plywood 5/8" or 3/4" thick can be used directly against studs without backing when the outer plies are at right angles to the studding. Structural plywood usually has five plies with


Double 2"x6" liners 8'-0" o.c. for all walls
3000# Minimum working strength ties. No metal to be left closer than 1½" of surface - ties with lugs - cones or washers to act as spreaders within form not permitted
1'-3"
1'-3"
2'-8"
2'-10"
8'-0"
8'-0"
8'-0"
2'-0"
4"x4" Studs at plywood joints
Double 2"x6" wales
2"x4" Studs 12" to 16" o.c.
¾" Plywood on outside face only
ELEVATION
Tie rod
Plywood joint
¾" Plywood on outside face only
Double 2"x6" wales
Double 2"x6" liners - bolt to all wales
Spacer sticks 6'-0" to 8'-0" o.c. to keep reinforcing required distance from face of wall - pull up as level of concrete rises
PLAN - SECTION

Form Layout for Use of Structural Plywood.

the fibers in the two outer and middle plies in one direction and the fibers of the other two plies in the opposite direction. Thus the plywood is stronger and stiffer in one direction than the other. The result may not be serious on the first use of the plywood and under average placing speed, but with faster placing the deflection may be pronounced. With the second use of

the plywood there will be noticeable deflection and on the third and additional uses, a deflection of ⅛" to ¼" can be expected with ¾" plywood on studs spaced 16" on centers.

Sometimes concrete form Presdwood is used as a form liner, which is usually nailed to decking or sheathing lumber as a backing. Board $\frac{3}{16}$" thick should be used over solid backing while ¼" board may be used semi-structurally. Ordinary wood working tools are used in cutting and applying Concrete Form Presdwood.

Some manufacturers advertise that plywood may be used 10 times or more in the construction of formwork but where appearance is important, it is seldom possible to use it more than 3 or 4 times. However, it may be used for other purposes where appearance is not so important.

When using plywood for the facade or facing forms it must be thoroughly cleaned after each use. Where a special form coating is used to treat the plywood instead of oil, it should be applied with care and allowed to dry thoroughly.

Architectural concrete walls must be straight and plumb. This is essential. It means that the 2"x4" or preferably 2"x6" studs and wales must be of uniform depth and perfectly straight, otherwise the walls will be crooked—with the possibility of the work being rejected.

The top of the foundation walls on which the architectural concrete wall rests must be perfectly level and straight, using two 2"x6" wales or similar planks, braced at intervals of not less than 4'-0", in addition to all other bracing ordinarily required for foundation walls. It requires about 4½ ft. of lumber, b.m. per lin. ft. of wall for these wales and bracing. In order to hold the studs of the form for the architectural concrete wall in line, it is necessary to insert ⅝" greased stud bolts, spaced about 3'-0" on centers, into the top of the foundation wall, as illustrated. It requires about $\frac{1}{8}$-hr. carpenter and $\frac{1}{16}$-hr. labor time per lin. ft. of wall to brace the top of the foundation wall and to insert the bolts.

As a rule, it is necessary to obtain a perfect horizontal line of the concrete at the top of the foundation wall, which will be assured by nailing a 1"x2" strip on the outside form of the foundation wall and placing the concrete about 1" higher than the bottom of this strip. About two hours after placing the concrete, the surplus concrete (which generally contains a good deal of laitance), is scraped off to the level of the under side of the strip.

Up to now we have endeavored to show how to obtain a per-

fectly straight line for the start of the forms for the architectural concrete walls.

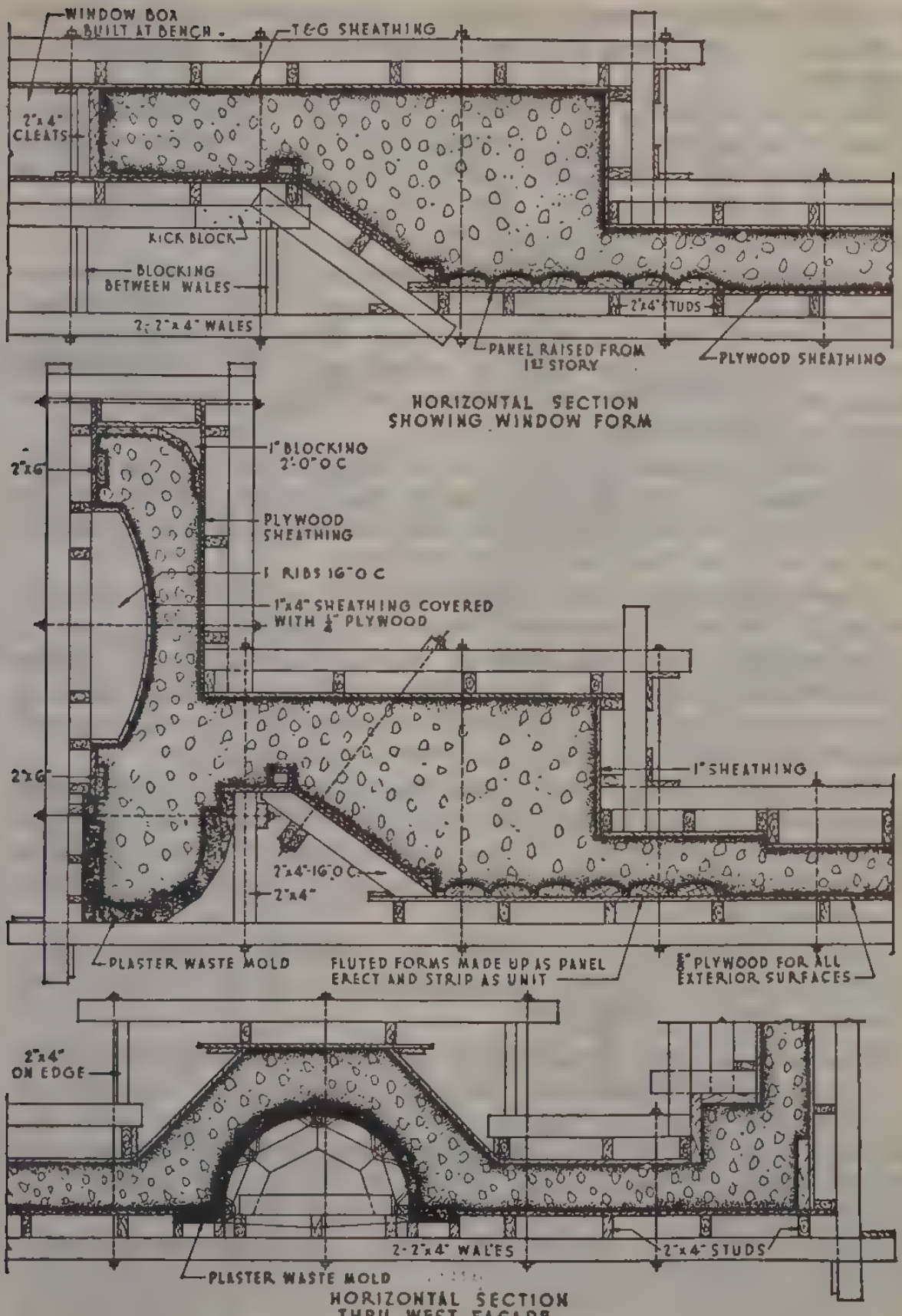
After the forms for the foundation walls have been stripped, the wales should be installed and blocked about 3'-0" apart against the foundation wall. The 2"x4" or 2"x6" studs should now be installed between wales and the wall. The studs should have 8d nails (protruding about 1") driven into the outside edge exactly 8" from the lower end and 6d nails (protruding less than ¾") exactly 8" from the lower edge. When inserting the studs between the wales and the foundation wall, the 8d nails form their support on the wales and the 6d nails furnish the support for the ¾" plywood. The studs are usually spaced 12" or 16" on centers but at every vertical joint in the plywood (usually 8'-0") a double stud or a stud 3½" wide should be used.

The studs are temporarily braced horizontally by nailing a 1"x6" board higher up and are braced vertically by wedging at the bottom between the studs and foundation wall. The first sheet of plywood is then inserted between the studs and the foundation wall and bolts, holding the wale tightened until the lowest part of the form is straight and plumb. The wales are spaced 24" vertically and the oiled tie bolts are spaced 2'-0", 2'-8" and 3'-4" apart, so that the holes do not interfere with the 16" stud spacing and are in proper relation to the ends of the 8'-0" long plywood sheets.

The arrangement of the holes for the tie bolts and the arrangement of the nails (6d box nails) by which the sheets of plywood are held to the studs are also shown in the accompanying illustration.

After 2 or 3 of the 4'-0" wide sheets of ¾" plywood have been fastened to the studs and the proper amount of horizontal walers put in place, the outside form is further strengthened by vertical wales consisting of 2 pcs. of 2"x6" spaced not more than 8'-0" on centers with about 2'-0" or more projecting over the top of the outside form. These wales are held in place and plumbed on top by two or more No. 9 or No. 10 wires, secured to column dowels, special bolts or other means provided in the foundations or in the floor. These vertical wales are bolted to every pair of horizontal wales they cross using ½" bolts. The form is now ready to support the vertical and horizontal reinforcing.

After the reinforcing steel has been placed, the inside form may be erected. The studs are nailed to a 1"x6" sill or plate, which has been nailed to the floor one day after concreting, and if the inside face of the wall is to have a finished appearance, requiring the use of plywood, the plywood should be in sheets



Method of Forming Waste Molds and Other Ornamentation in Architectural Concrete Forms

24" wide and 8'-0" long in order to facilitate the nailing of the plywood to the studs and the insertion of the tie bolts and spreaders.

The joints of the plywood should be filled with a mastic consisting of a mixture of 50 percent tallow and 50 percent cement for summer use, while for winter work, the tallow should be replaced by pump grease. The surplus filler should then be scraped off using No. 0 sandpaper.

Estimating Quantities for Architectural Concrete Forms.—When estimating the quantities for plain architectural concrete walls, do not make any deductions for ordinary door and window openings, as these must be formed with the wall and then boxes built in to allow for the door or window frame to be inserted at a later date.

The only exception to this rule is where there are large display windows in the first story of a commercial building or for skeleton type buildings where the piers and lintels are estimated at a higher rate than plain wall surfaces.

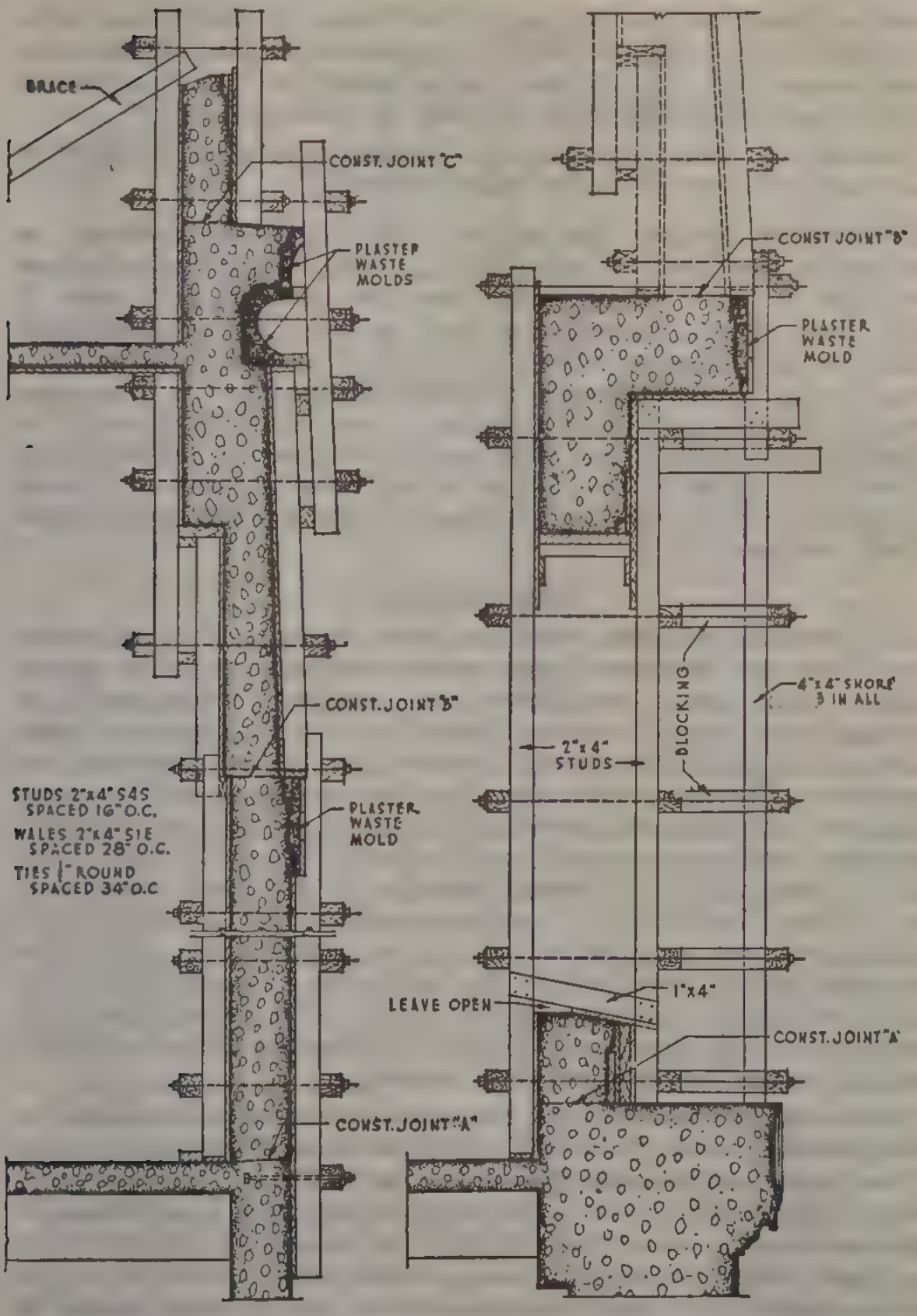
All ornamentation should be estimated separately, either by the lin. ft. or sq. ft. depending upon the class of work.

Ornamental work will require the use of wood or plaster waste molds for forming, in addition to the structural backing, so that the entire wall area should first be figured as plain wall surfaces and then all ornamentation figured extra.

Water tables, belt courses, cornices, door and window trim, copings, etc., should be estimated by the lin. ft. when less than 12" wide and by the sq. ft. when more than 12" wide. Always mention size and detail for each type of ornamentation, as this is necessary for pricing the work.

Columns, pilasters, etc., should be estimated separately, giving width, height and area in sq. ft. together with a detail of the forming, whether fluted, etc.

Window and Door Openings in Architectural Concrete Walls.—It is necessary to form for all door and window openings in concrete walls, i.e., the outside wall form is built up solid and then boxes or "bucks" are constructed the exact size of the door and window openings. They should be made of 2" lumber and held in place by 1"x4" strips nailed to both the outside and inside wall sheathing and braced where necessary using 2"x4"'s placed horizontally and diagonally. Where the opening is over 3'-0" wide it will be necessary to leave an opening in the bottom of the frame so that concrete can be filled to the proper level. After filling to the correct level, the opening is closed, nailing a



Method of Forming for Architectural Concrete Waste Molds for Belt Courses and Cornices

piece of plank to the bottom of the frame. A few hours after the concrete has set, the plank is removed and the surplus concrete scraped off. To do this, it is necessary to leave an opening in the inside form at every opening, as illustrated.

Reveals for door and window openings should be designed so that standard size 2" lumber may be used.

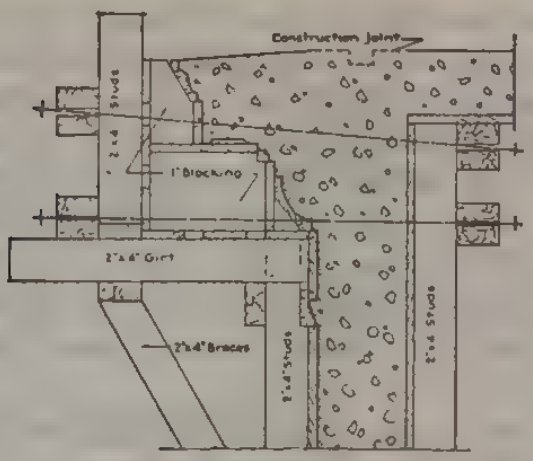
Rustication Strips.—Rustication strips should be designed as narrow as possible and only about ¾" deep. When the strips are less than 1" wide, they should have one saw cut and when 2" wide, they should have 2 saw cuts in the back as illustrated. These strips should be nailed to a chalk line, using casing nails long enough to go through strip and sheathing. It is recommended that the nails be withdrawn by pulling them through the sheathing before the form is removed and allow the wooden strip to remain in place a few days after the form is removed or long enough so that they can be withdrawn without injuring the edges of the concrete.

Ornamentation

Belt courses or other ornamentation where continuous members occur may be formed with wood moldings cut to the proper shape. While some contractors may prefer a waste mold for this particular detail, the wood mold has the advantage of being more easily held in alignment because the various members are broken at different points, while in a plaster waste mold the entire form would be cut in two at one point. Soft grained wood that does not warp or split easily should be used. Soft white pine is best with soft-grained Douglas fir a second choice. In the cornice illustrated, the various members are narrow enough so that common stock sizes can be used throughout. Note the generous use of saw-kerfs in the back side of members to prevent swelling and warping of the lumber. The lumber should be thoroughly oiled on all sides before building the forms as further precaution against swelling and warping.

Large, heavy wood members should be avoided in detailing for ornamental work as they will swell and in stripping, the corners of the projecting concrete will be fractured. Using several smaller pieces requires less lumber and the members may be arranged so that swelling is away from the concrete, making it easier to strip the form without damage to the concrete corners. Note the illustration where the left-hand detail shows a large member milled from a single wide board in contrast to the smaller pieces shown in the right-hand detail.

In assembling forms one must keep constantly in mind the



Wood Mold Used in Cornice Form.

steps that can be taken to aid in removing them without injury to the concrete. Boxes, waste molds, wood molds, rustication strips or anything applied to the face of the forms should be nailed lightly so that when the forms are removed, these members will pull loose from the wall form and remain in the concrete. After these materials have dried out thoroughly and thus have shrunk, they can be removed without much difficulty and without injury to the concrete corners or edges.

As previously indicated, solid strips of wood, even though well oiled, may swell and result in considerable breakage of concrete corners when the strips are removed. Saw-kerfs on the back of the member will prevent this trouble by relieving any pressure against the concrete. They should be approximately two-thirds the depth of the member, not more than 1½" apart and, in general, there should be one kerf within ¾" of each edge.

Waste molds are the only solution for some highly ornamental work. They should be made only by experienced ornamental plaster workers who have been given instructions as to how they are to be fitted into the forms. Ordinarily, the waste molds are about 2" thick, reinforced on the back with 2"x4"s which are attached to the mold with burlap dipped in plaster and then wound around the wood. The 2"x4"s permit easy handling of the mold and are also used to attach the mold to the form.

When waste molds are large and have deep undercuts, it is usually best to wire them back to the studs or wales with enough wires to be sure that all points will be pressed firmly against the form. Any openings between the form and waste mold should be pointed with plaster of Paris or a patching plaster and nailheads driven through the face and around the edge of the waste molds should be countersunk and similarly pointed.

Ornamental Concrete Cornices.—Where it is necessary to use molds for belt courses, cornices, door and window reveals, columns, cornices, entrances, etc., it is more economical to build them of wood, if practicable. However, if plaster waste molds are required, the following will give some idea of their cost, although on this work, it is always advisable to obtain definite prices from a concern specializing in this work.

Plain molds consisting of a few straight lines, $3.00 per sq. ft.

Ordinary molds of stock design will cost from $3.00 to $4.00 per sq. ft.

Simple models will cost from $3.00 to $4.00 per sq. ft. plus the cost of waste molds, as given above.

Cornice molds of stock design about 1′-6″ deep and 1′-3″ wide cost about $6.00 to $8.00 per lin. ft.

Capitals for 1′-6″ pilasters, stock designs, cost $50 to $60 each.

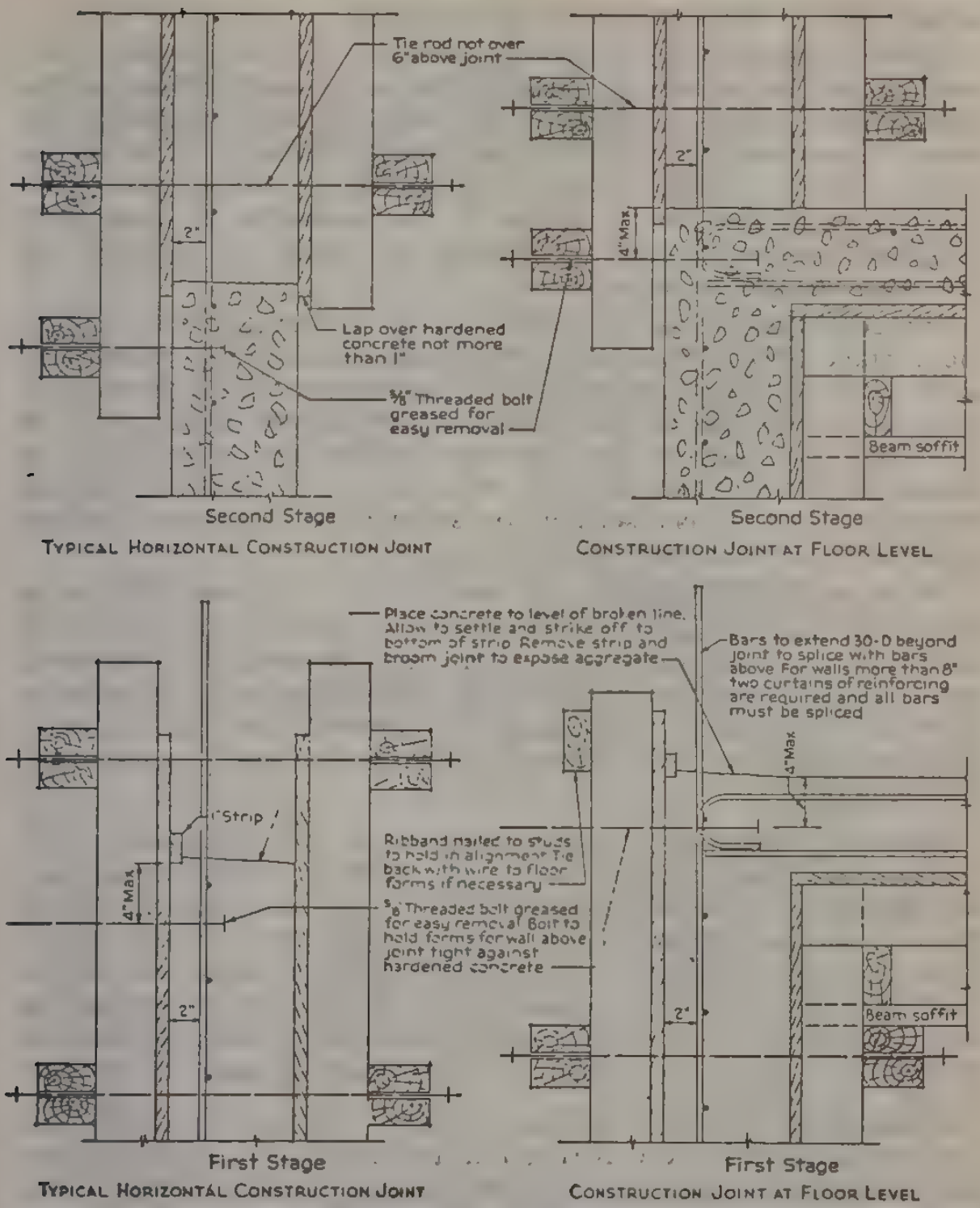
Joints in plaster waste molds should be patched with non-shrinking patching plaster and painted with shellac.

Individual pieces should not weigh more than 150 lbs. to be set without difficulty by 2 men.

Plaster waste molds are usually given 2 coats of shellac in the shop to make them waterproof and non-absorbent. Before concrete is placed all molds should be greased with a light yellow cup-grease, which may be cut with kerosene if too thick. The grease should be wiped into all angles of the mold and every bit of surplus grease carefully wiped off. Care must be taken not to drop oil, grease or shellac onto hardened concrete or reinforcing.

Construction Joints.—Much progress has been made on all types of concrete work in the production of satisfactory construction joints, both from the standpoint of good appearance and good bond between the successive lifts. On the other hand, some very unsightly joints for which there is no excuse occasionally are made on architectural concrete work. It is just as easy to produce a good joint as a poor one. The designer, of course, should indicate on his plans exactly where such joints should be located. Rustications or offsets will mask the joints and are advisable where they can be made to fit into the design.

One requirement that is sometimes neglected is to provide means of holding the form tightly against the hardened concrete. As a result, leakage occurs, discoloring the concrete below and the upper lift will project slightly beyond the lower lift. The illustration shows the use of ⅝″ bolts cast in the concrete for fastening the form for the next lift. Some types of form ties can be used instead of bolts. The bolt or form tie assembly


Tie rod not over 6" above joint
2"
Lap over hardened concrete not more than 1"
⅜" Threaded bolt greased for easy removal
Second Stage
Typical Horizontal Construction Joint
2"
4" Max.
Beam soffit
Second Stage
Construction Joint at Floor Level
Place concrete to level of broken line. Allow to settle and strike off to bottom of strip. Remove strip and broom joint to expose aggregate
Bars to extend 30-D beyond joint to splice with bars above. For walls more than 8" two curtains of reinforcing are required and all bars must be spliced
4" Max.
1" Strip
4" Max.
Ribband nailed to studs to hold in alignment. Tie back with wire to floor forms if necessary
⅝" Threaded bolt greased for easy removal. Bolt to hold forms for wall above joint tight against hardened concrete
2"
First Stage
Typical Horizontal Construction Joint
2"
Beam soffit
First Stage
Construction Joint at Floor Level

Method of Embedding Bolts and Placing Forms for Successive Lifts.

can be used over and over, as only the nut is left in the concrete if the bolt is used, or the insert if a form tie is used. In re-erecting the forms for the next lift, the contact surface of the form sheathing should not overlap the hardened concrete more than 1". More overlapping than this only presents more opportunity for leakage due to irregularities in the wall surface

against which the sheathing is to be held.

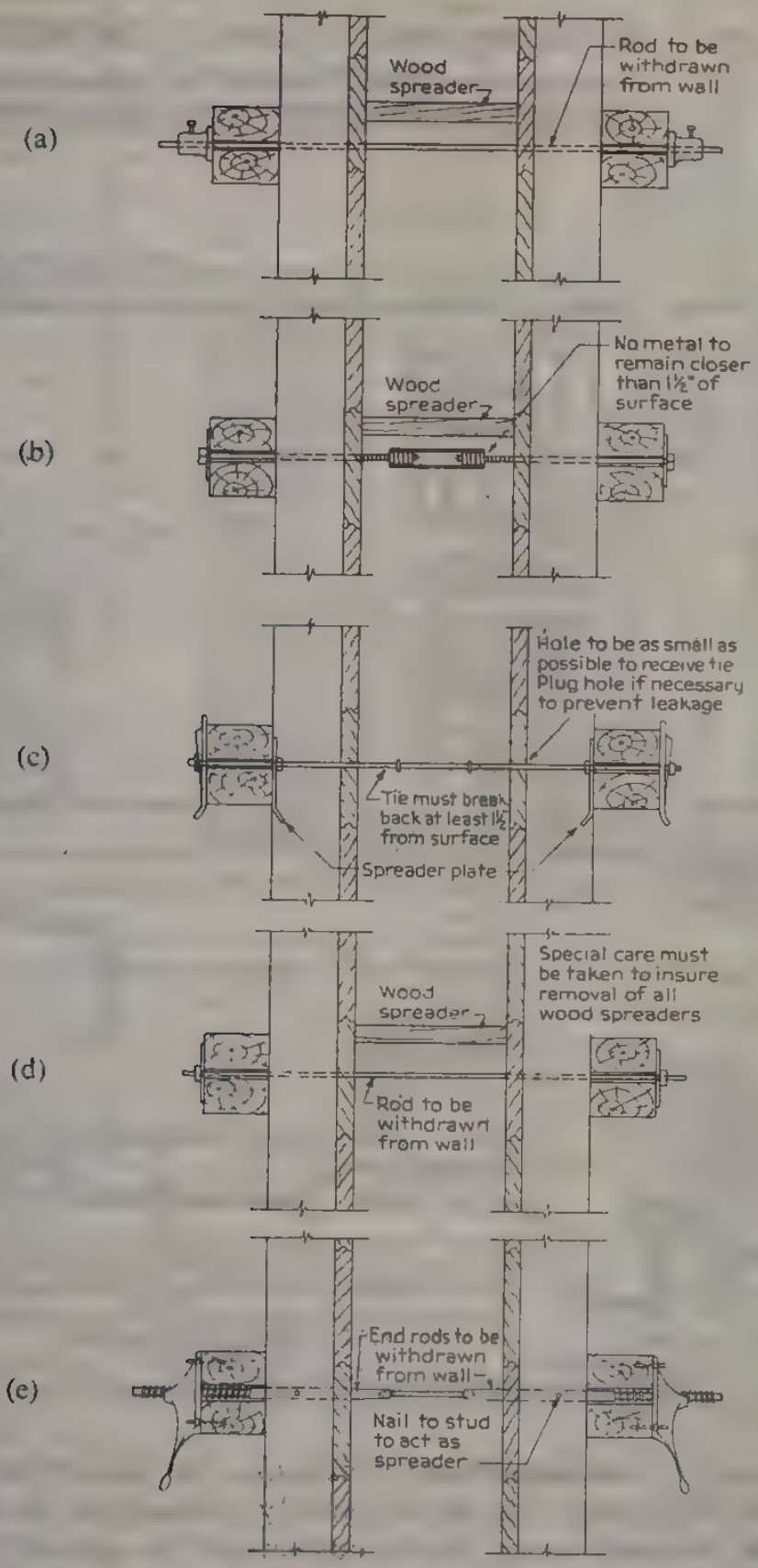
Since sufficient time must be allowed for the concrete between windows or other openings to settle and shrink before the concrete above is placed, the tops of such openings are "must" locations for construction joints. Similarly, it is desirable to locate a joint at the sill line. By so doing the joints are broken up into short lengths by the openings, making them relatively inconspicious. Moreover, cracking at corners of openings is thereby minimized.

The construction joint should be only a straight thin line at the surface. If a rustication strip is not used at the joint, a ¾" wood strip should be nailed to the inside face of the form. The concrete should be placed to a point ½" above the bottom of this strip and just before the concrete becomes hard, the top should be lightly tamped to be sure that it is tight up against the strip after it has settled, or shrunk. All surplus concrete or laitance should then be removed.

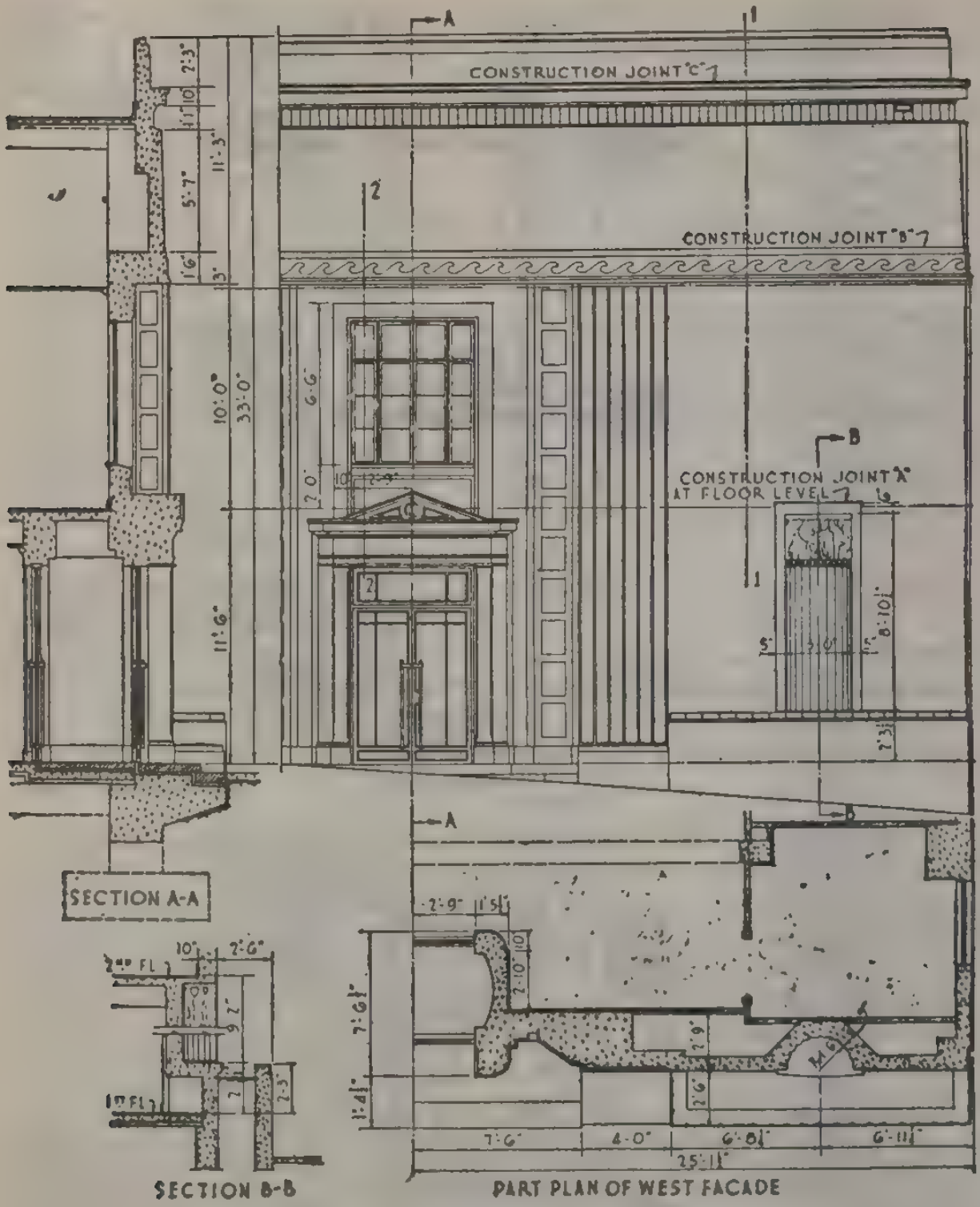
In resuming the placing of concrete in the new lift, steps should be taken to get good bond and to avoid honeycomb. The hardened concrete should be clean and thoroughly saturated. A 6" layer of concrete in which the coarse aggregate is reduced about 50 percent, or a 2" layer of cement-sand grout should then be placed on the hardened concrete followed by the regular concrete.

Control Joints.—It is important, both for appearance and performance, that control joints be carefully installed so they will be perfectly straight and vertical. Care is required during placing of concrete to avoid knocking the joint out of alignment or otherwise injuring it. When control joints are to be caulked with a plastic compound, this should be done before the final clean down so that any compound smeared onto the surface is removed. Of course, excessive smearing should be avoided.

Form Ties.—Various makes of form ties are available for architectural concrete construction as shown in the accompanying illustration. Important features to look for in selecting form ties are: removal of all metal to a depth of at least 1½" from the face of the wall, minimum strength of 3,000 lbs. when fully assembled, adjustable length to permit tightening of forms around all openings and inserts and a design that will leave a hole at the surface not more than ⅞" in diameter and not less than ¾" deep so that it will hold a patch. Ties should not be fitted with cones or washers acting as spreaders, as tapered and shallow holes cannot be patched properly.


(a)
Wood spreader
Rod to be withdrawn from wall
(b)
Wood spreader
No metal to remain closer than 1½" of surface
(c)
Hole to be as small as possible to receive tie Plug hole if necessary to prevent leakage
Tie must break back at least 1½" from surface
Spreader plate
(d)
Wood spreader
Special care must be taken to insure removal of all wood spreaders
Rod to be withdrawn from wall
(e)
End rods to be withdrawn from wall
Nail to stud to act as spreader

Types of Form Ties Available for Use in Architectural Concrete Construction.



Details of Architectural Concrete Facade

Labor Cost of Architectural Forms.—The labor fabricating, erecting and stripping forms is usually estimated on the basis of sq. ft. of contact area. It is customary on a job having a normal amount of ornamentation to take off the total contact area as though the wall were plain. Window and other openings,

unless very large, are figured solid. The area thus obtained is priced as though the wall were unornamented. Separate allowance is made for window frames or "bucks", ornamentation, etc.

The average amount of lumber required for plain wall forms is 2¼ to 2½ ft. b.m. of lumber per sq. ft. of contact area, plus the sheathing, plywood or Concrete Form Presdwood, used for the facing materials. Figure one tie rod for approximately each 10 sq. ft. of form.

On plain walls up to 10 ft. story height, it requires about 11 to 13 hrs. carpenter time and 6 to 8 hrs. labor time per 100 sq. ft. of contact area. For walls 12 to 14 ft. high, add about 10 percent to these costs. This includes all time necessary for erecting and stripping the forms and hoisting it up for the next use. In addition, figure about 1 to 1¼ hrs. labor time for removing hardened concrete from plywood and coating same between each use.

Door or window frame boxes or "bucks" require 5 to 8 hrs. carpenter time for each opening, depending upon size and detail of same.

Rustication strips should be placed at the rate of 25 to 30 lin. ft. an hr. for one carpenter.

Ornamental curtain walls, fluted pilasters and piers, reveals, etc., will require about 10 to 12 hrs. carpenter time and 6 hrs. labor time per 100 sq. ft. in addition to the cost of plain wall forms.

Ornamental wood cornices built to special detail will require 24 to 28 hrs. carpenter time and 12 to 14 hrs. labor time per 100 sq. ft. in addition to cost of plain wall forms.

Ornaments projecting from the face of plain walls, such as special sills, balconies, etc., will require about 36 to 40 hrs. carpenter time and 12 to 15 hrs. labor time per 100 sq. ft. in addition to the cost of plain wall forms.

Where plaster waste molds are used, they may be set either by carpenters or plasterers, depending upon local labor union regulations.

When setting simple belt courses of plaster waste mold, allow 12 to 14 hrs. mechanic time and 6 to 7 hrs. helper time per 100 sq. ft.

When erecting and blocking cornices and other elaborate moldings using plaster waste molds, figure 20 to 25 hrs. mechanic time and 10 to 12 hrs. helper time per 100 sq ft.

When placing letters, a carpenter should set 2 to 3 letters an hr. depending upon size.

Cost of 100 Sq. Ft. of Plain Architectural Concrete Walls Using Plywood for Facing Material

	Hours	Rate	Total	Rate	Total
250 ft. framing lumber		$.....	$.....	$0.06*	$ 15.00*
120 sq. ft. ¾" plywood		.....	.....	.12*	14.40*
Nails, tie rods, etc.		.....	.....	.03	3.00
Carpenter erecting forms	12.0	.....	.....	6.75	81.00
Labor helping	6.0	.....	.....	5.00	30.00
Labor stripping and cleaning forms	2.0	.....	.....	5.00	10.00
Labor coating plywood.	0.33*	.....	.....	5.00	1.67*
Form coating		.....	.....	.01	1.00*
Cost 100 sq. ft. forms	20.33		$.....		$156.07
Cost per sq. ft.			.....		1.561
Material cost per sq. ft.			.....		.334
Labor cost per sq. ft.			.....		1.227

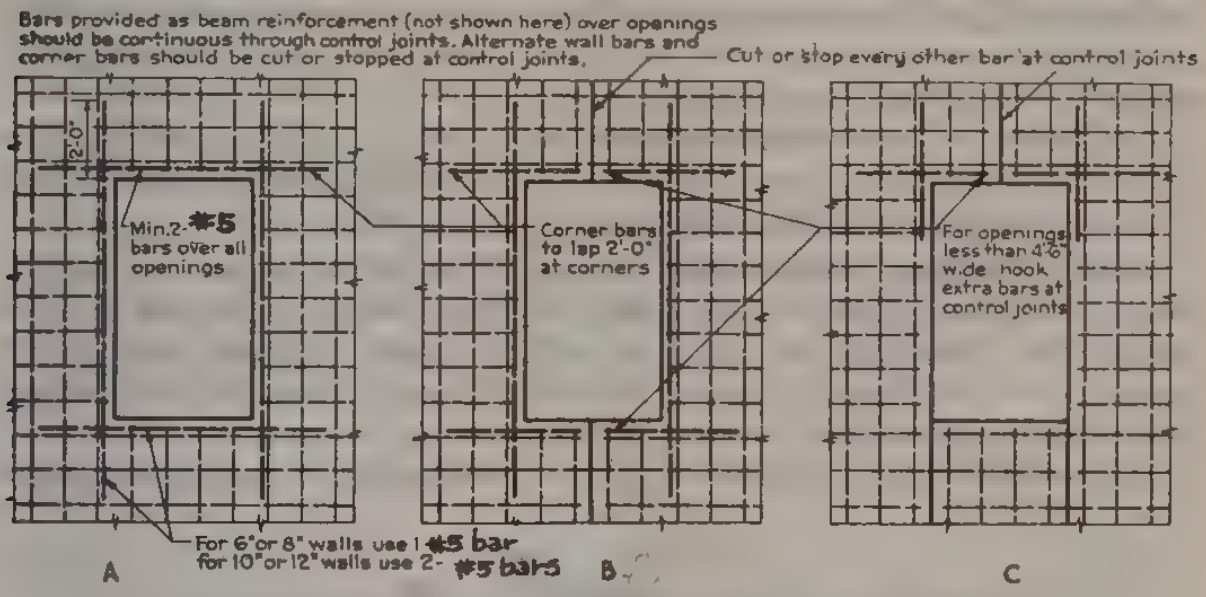
Cost of 100 Sq. Ft. of Plain Architectural Concrete Walls Using ¾" Sheathing for Facing Material

	Hours	Rate	Total	Rate	Total
250 ft. framing lumber		$.....	$.....	$0.06*	$ 15.00*
120 ft. sheathing lumber		.....	.....	.05*	6.00*
Nails, tie rods, etc.		.....	.....	.03	3.00
Carpenter erecting forms	12	.....	.....	6.75	81.00
Labor helping	6	.....	.....	5.00	30.00
Labor stripping and cleaning lumber	2	.....	.....	5.00	10.00
Cost 100 sq. ft. forms	20		$.....		$145.00
Cost per sq. ft.			.....		1.450
Material cost per sq. ft.			.....		.240
Labor cost per sq. ft.			.....		1.210

*Lumber and form coating cost based on using each set of forms 3 times.

Details for Architectural Concrete Forms.—For the rapid and economical construction of architectural concrete forms, it is necessary to have complete working drawings, which should show the elevations in large scale, together with every piece of plywood, every stud, wale, bolt, lumber for reveals, window boxes or "bucks," etc., similar to the methods used for detailing cut stone, terra cotta or structural steel.

In a well equipped office under competent supervision, such drawings should cost from 1½ to 2½ cts. per sq. ft. of forms.


Bars provided as beam reinforcement (not shown here) over openings should be continuous through control joints. Alternate wall bars and corner bars should be cut or stopped at control joints.
Cut or stop every other bar at control joints
2'-0"
Min. 2-#5 bars over all openings
Corner bars to lap 2'-0" at corners
For openings less than 4'-0" wide hook extra bars at control joints
For 6" or 8" walls use 1-#5 bar
for 10" or 12" walls use 2-#5 bars
A
B
C

Alternate Methods of Placing Reinforcing around Openings.

Reinforcing Steel

Although it is practically impossible to provide sufficient reinforcement to prevent cracking in a long wall and for that reason control joints are used, it is necessary and practical to provide adequate reinforcement between joints when properly spaced to resist volume change stresses. To be most effective small bars with a type of deformation to give maximum bond should be placed relatively close together rather than using larger bars at wider spacings. Generally #3 bars are preferable to larger sizes and the horizontal reinforcement should be at least equal to 0.25 percent of wall area. In the vertical direction 0.15 percent reinforcement is sufficient.

The size and spacing of bars recommended for walls of various thickness are given below:

Wall thickness in.	Horizontal reinforcement	Vertical reinforcement
6	#3@8" in outside face of wall	#3@8" in outside face of wall
8	#3@6" in outside face of wall	#3@8" in outside face of wall
10	#3@10" in both faces of wall	#3@12" in both faces of wall
12	#3@8" in both faces of wall	#3@12" in both faces of wall

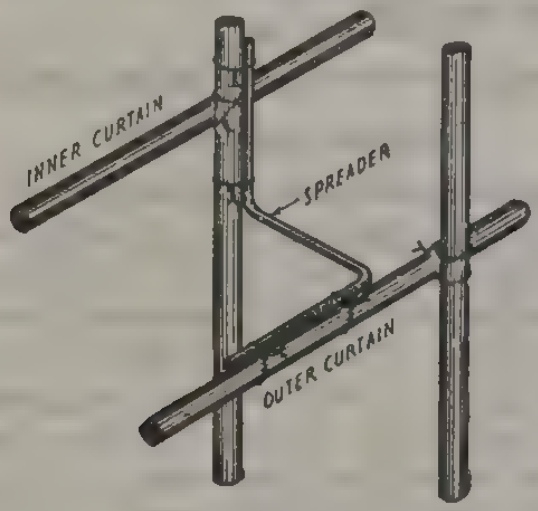
Recommended Size and Spacing of Reinforcing Bars in Concrete Walls.

The bars should be tied at each intersection with a non-slip tie and where two curtains of steel are used it is advisable to include a detail drawing to show how the curtains are to be fastened together with tie spreaders at frequent intervals to make a rigid web of reinforcement.

Difficulty is sometimes experienced in placing concrete in walls because of a congestion of reinforcing bars and this condition should be avoided insofar as practicable.

Labor Placing Reinforcing Bars.—The labor cost of placing reinforcing steel in architectural concrete walls is expensive on account of the small size of the rods, the fact they run both horizontally and vertically, must be wired together and the cramped quarters in which the men must work.

On walls 8 to 12 inches thick, a reinforcing steel setter will



Tie Spreader.

handle, place and wire 750 to 850 lbs. of reinforcing steel per 8-hr. day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Reinforcing steel setter	20	$.....	$.....	$7.10	$142.00

Concrete Quality and Placement

Architectural concrete demands the use of a plastic, workable mix that can be worked and molded readily in the forms. Surfaces of the hardened concrete should be free of defects such as sand streaking and honeycomb. It is important that sufficient fines be provided in the mixture and for these reasons the fine aggregate should have at least 15 percent passing through a 50 mesh sieve and 3 percent passing the 100-mesh sieve and the cement factor should not be less than 5½ sacks per cu. yd. of concrete. In other words, the concrete should not

be richer than 1:2:3 by loose volumes and preferably 1:2⅓:3⅓, containing 6½ or 6 sacks of cement per cu. yd. of concrete respectively. Hard limestone will show less cracking than most gravels.

Not more than 6½ gals. of water per sack of cement should be allowed so that the concrete will have the durability required to withstand weathering.

Mixing and Placing Concrete.—Concreting of architectural concrete walls should proceed at a rather slow rate allowing sufficient time for thorough vibrating at the finished surfaces so that the pressure exerted by the concrete on the forms does not exceed 600 lbs. per sq. ft.

Do not use a mixing plant that is too large. It is better to select a plant of such size that some concrete can be placed each day, insofar as this is practical. It is more economical and usually results in better quality concrete.

A reasonable rate of placing the concrete should be considered when locating joints. Generally a rate of not more than 2 feet an hour is most conductive to good workmanship and lifts of 6 to 8 feet between joints are desirable and 12 feet should be the absolute maximum.

When using mixers too large for the job, there is a tendency to build up layers of the fresh concrete that are too thick. This may result in wavy lines of discoloration on the surface. Layers of fresh concrete should be kept to a maximum of 18 inches and less than this is preferable.

The concrete should be spaded or vibrated into all corners and along all form surfaces, but even if vibrated, some spading is necessary in the corners and angles as vibrators will not fill these places at all times. On many jobs small electric hammers moved along the forms at the point of placement have been found helpful. Vibration should be sufficient only for complete compaction, not to the point where segregation occurs and excess water is forced to the form faces. Such over-vibration may result in sand streaking and discoloration.

When concrete is splashed on the forms above the point of deposit and subsequently hardens, the wall in that area is likely to be rough and discolored. Splash boards are sometimes used but are not completely satisfactory as they do not prevent segregation of the falling concrete. Rectangle metal tremies of various lengths equipped with a hopper at the top through which the concrete is placed will avoid both splash and segregation. The tremies should be spaced not more than about 9 feet apart. Sometimes splashing is the result of mortar being thrown from

vibrators as they are lifted out of the concrete and raised to the placing platform. This can be prevented by shutting off the power as the vibrator is withdrawn from the concrete.

Labor Placing Concrete.—The labor cost of placing architectural concrete will vary considerably, depending upon the size of job, size of sections, amount of ornamentation, quantity of reinforcing steel, etc., but on most work of this class, it will require 4 to 5 hours labor time per cu. yd. of concrete, plus the time for mixer and hoisting engineer and foreman.

Based on a 64-cu. yd. pour per 8-hr. day, the labor cost should average as follows per cu. yd.:

	Hours	Rate	Total	Rate	Total
Foreman	0.13	$.....	$.....	$5.25	$ 0.68
Mixer engineer	0.13	.....	.....	6.00	0.78
Hoist engineer	0.13	.....	.....	6.00	0.78
Labor	4.50	.....	.....	5.00	22.50
Cost per cu. yd.	4.89		$.....		$24.74

Approximate Quantities of Materials Required for One Cu. Yd. of Architectural Concrete Walls

Surface Dry Aggregates

	Rate	Total	Rate	Total
6 sacks portland cement...	$.....	$.....	$1.80	$10.80
1,290 lbs. sand (0.48 cu. yds.)	.....	.....	4.00	1.92
1,920 lbs. gravel (0.71 cu. yds.)	.....	.....	4.00	2.84
Cost per cu. yd. concrete.		$.....		$15.56

Damp Aggregates

	Rate	Total	Rate	Total
6 sacks portland cement...	$.....	$.....	$1.80	$10.80
1,425 lbs. sand (0.53 cu. yds.)	.....	.....	4.00	2.12
2,040 lbs. gravel (0.75 cu. yds.)	.....	.....	4.00	3.00
Cost per cu. yd. concrete.		$.....		$15.92

Curing.—On this type of work one of the surest and best ways of curing the concrete is by leaving the forms in place. Whenever it is practical to do so, they should be left in place 4 or 5 days. By that time the concrete is hard enough so that it is not scuffed nor are corners so likely to be broken off during form removal. If the forms are removed earlier, other means must be provided to keep the concrete wet or damp for at least 5 days if a durable concrete is to be obtained.

Patching and Finishing.—When the forms are first stripped, the concrete does not always present a pleasing appearance as there may be pock marks, air holes, fins and some discoloration. Some of the latter will bleach out upon exposure but a simple clean down with cement grout will do wonders for the appearance. The projecting fins and other blemishes extending beyond the face of the wall are removed with a carborundum stone or abrasive hone and then a grout of 1 part portland cement to 1½ parts of very fine sand (sand passing through a fly screen will do) is applied. From ⅓ to ½ of the cement should be white cement.

The grout is mixed to the consistency of a heavy paste. After the wall is wet down, the grout is applied uniformly with a stiff fiber brush, completely filling all air voids and holes. Immediately after the grout has been applied, the wall is floated with a wood or cork float. A very fine abrasive hone can also be used. The grout is then allowed to harden partially, the exact time depending upon the weather. When it is hardened sufficiently so it will not be pulled out of the holes, all grout is scraped from the surface of the wall with the edge of a steel trowel. After the wall has dried thoroughly, it is rubbed with a dry piece of burlap to completely remove all of the dried grout or film. There should be no visible film left on the surface. Grout should not be left on the wall overnight. All cleaning of any one panel of concrete should be completed the same day.

Patching mortar used to fill tie holes and imperfections should be of the same mixture of gray and white cements, but should be a stiffer mixture and the cement and sand proportions should be the same as those used in the concrete. Patches should never be steel troweled, but may be finished with wood or cork floats. Allowing the mixed patching mortar to stand for an hour or two before using it reduces the amount of shrinkage but water must not be added in remixing it.

Cost of One Cu. Yd. of 1:1½ Portland Cement Grout Used for Patching and Grouting Architectural Concrete Surfaces

	Hours	Rate	Total	Rate	Total
7.6 sacks portland cement..		$.....	$.....	$1.80	$13.88
7.6 sacks white portland cement		.....	.....	4.00	30.40
0.84 cu. yds. sand		.....	.....	4.00	3.36
Cost per cu. yd.			$.....		$47.64
Cost per cu. ft.			.....		1.76

Patching Bolt Holes in Architectural Concrete Walls.—After the forms have been stripped, it will be necessary to neatly patch

all bolt holes at the exposed surfaces and to correct any blemishes appearing on the face of the walls, also some patching may be necessary, as described above. It is not safe to figure less than 3 to 5 hrs. time for cement finisher and helper per 100 sq. ft. of wall (wall measured one side only), and the cost per 100 sq. ft. of wall should average as follows:

	Hours	Rate	Total	Rate	Total
Cement mason	4	$.....	$.....	$6.50	$26.00
Helper	4	.....	.....	5.00	20.00
Cost per 100 sq. ft. wall	8		$.....		$46.00
Cost per sq. ft. of wall					.46

Add for cement and sand.

CHAPTER IX

CONCRETE FLOORS AND WALKS; LIGHTWEIGHT CONCRETE; CONCRETE CURB, GUTTER AND PAVING

Concrete floors, sidewalks, and slag, cinder or lightweight concrete floor fill are estimated by the sq. ft. taking the number of sq. ft. of any given thickness, as 2", 3", 4", 5", 6", etc.

The quantities are easily computed by obtaining the area of the various rooms or spaces to have concrete floors or walks and stating the number of sq. ft. of each thickness.

When preparing an estimate for concrete floors or sidewalks placed on the ground, there are eight distinct material and labor items to be considered as follows:

1. Labor grading and removing surplus earth under floors or walks or filling where present grade is too low.
2. Cost of cinders, sand, gravel or slag to be placed under concrete floor; labor spreading and tamping same in place.
3. Labor placing wood or metal screeds or forms.
4. Cost of cement, sand and gravel for concrete subfloor.
5. Labor mixing and placing rough concrete subfloor.
6. Cost of cement, sand and coarse aggregates for finish top, also cost of floor hardening compound, if specified.
7. Labor mixing, placing and troweling cement finish top and blocking off into squares, if required.
8. Cartage of plant and equipment, insurance, profit, etc.

Grading for Concrete Floors and Walks.—On practically all cement floors and walks placed directly on the ground it is necessary to do a certain amount of grading before the bed of cinders, sand, gravel or slag can be placed.

If the space is large and it is not necessary to remove the excavated soil from the premises, a bulldozer or tractor shovel is probably the most economical method to use.

A medium size bulldozer and operator should excavate and place in piles, 20 to 25 cu. yds. per hour at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Bulldozer	0.045	$.....	$.....	$5.70	$0.26
Operator	.045	.....	.....	6.75	0.30
Cost per cu. yd.	.09		$.....		$0.56

This cost will vary with the kind of soil encountered, i.e.,

sand or loam, ordinary black soil, heavy soil or clay. Detailed excavating costs are given in chapter on "Excavating."

Number of Sq. Ft. of Soil of Various Thicknesses Obtainable From One Cu. Yd.

	Depth of Excavation in Inches									
One cu. yd.	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"
27 cu. ft.=	108	81	65	54	46	40	36	32	29	27

To obtain the cost of grading one sq. ft. of any thickness, divide the cu. yd. cost by the number of sq. ft. obtainable from one cu. yd. and the result is the sq. ft. cost for grading. Example: With excavating at $0.50 per cu. yd. find the sq. ft. cost of removing 5" of top soil. The table shows that one cu. yd. contains 65 sq. ft. of 5" fill. $0.50÷65=.0077 or approx. $\frac{8}{10}$ cent per sq. ft. for grading.

Hand Grading.—If the top soil is loaded by hand into wheelbarrows or power buggies, a man should loosen, shovel and load 5 to 6 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	1.45	$.....	$.....	$5.00	$7.25

Grading and Tamping Cinders, Sand or Slag Fill Under Concrete Floors or Walks.—Where cinder, sand, gravel or slag fill is placed under concrete floors or walks, the cost will vary with the thickness of the fill and job conditions, i.e., whether necessary to load into wheelbarrows and wheel from street or whether it can be spread from piles.

It costs as much to grade and tamp a bed of slag or cinders 3" thick as one 9" thick, because it is only the surface that is graded and tamped and the only additional labor on the thicker fill is for handling and spreading a larger quantity of material.

Where the fill varies from 3" to 4" thick, a man will spread, grade and tamp about 6 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	1.33	$.....	$.....	$5.00	$6.65

If the fill varies from 5" to 6" thick, a man will spread, grade and tamp about 8½ cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.94	$.....	$.....	$5.00	$4.70

If the fill varies from 7" to 9" thick, a man will spread, grade and tamp about 10½ cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.76	$.....	$.....	$5.00	$3.80

A man will spread, grade and tamp about 12½ cu. yds. of 10" or 12" fill per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.64	$.....	$.....	$5.00	$3.20

Spreading and Grading Using a Bulldozer.—If a small bulldozer may be used to spread and grade the floor fill, a machine and operator should spread 25 to 30 cu. yds. an hour without too much trouble, at the following labor cost per cu. yd. and per sq. ft. of various thickness:

	Hours	Rate	Total	Rate	Total
Bulldozer	0.04	$.....	$.....	$4.20	$0.17
Operator	.04	.....	.....	6.75	0.27
Cost per cu. yd.	0.04		$....		$0.44
Cost per sq. ft.—4" thick (81 sq. ft.)			.....		.0054
Cost per sq. ft.—5" thick (65 sq. ft.)			.....		.0068
Cost per sq. ft.—6" thick (54 sq. ft.)			.....		.0082
Cost per sq. ft.—8" thick (40 sq. ft.)			.....		.0110

Add cost of tamping to the above.

Number of Sq. Ft. of Fill of Various Thicknesses Obtainable From One Cu. Yd. Before Compaction

	Thickness of Fill in Inches										
One cu. yd.	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"
27 cu. ft. =	162	108	81	65	54	46	40	36	32	29	27

All fill materials will shrink under compaction—some more than others—and the additional material required to make up the deficiency due to shrinkage, together with the additional labor for handling same, must be provided for in the estimate.

The best and easiest way to do this is to increase the quantity before pricing by applying the proper shrinkage factor for the material to the net computed volume.

For example: If an area 100'-0" x 50'-0" is to receive a cinder fill 6-inches thick after tamping, the gross volume of cinders would be 100'-0" x 50'-0" x 0'-6" x 1.30=3,250 cu. ft. or approximately 121 cu. yds. In the computation, 1.30 is the shrinkage factor for cinders.

The following table gives approximate values for shrinkage percentages and shrinkage factors for various fill materials:

Material	Shrinkage Percentage	Shrinkage Factor
Cinders	30	1.30
Crushed Limestone	20	1.20
Granulated Slag	15	1.15
Gravel	12	1.12
Sand	8	1.08

To obtain the cost of one sq. ft. of fill of any thickness, divide the cost per cu. yd. by the number of sq. ft. obtainable from one cu. yd., multiply by the shrinkage factor and the result is the sq. ft. cost. Example: Find the cost of one sq. ft. of 6" cinder

fill with cinders at $1.75 per cu. yd. The table shows it is possible to obtain 54 sq. ft. of fill from one cu. yd. of cinders before compaction, $1.75÷54 x 1.30=.0421 or approx. 4¼ cts. per sq. ft.

The labor cost is obtained in the same manner.

Forms or Screeds for Concrete Sidewalks.—It is customary to use 2″x4″ or 2″x6″ lumber for forms at each side of a concrete sidewalk, the depth of the forms depending upon the thickness of the concrete. On ordinary sidewalk work, obtain the number of lin. ft. of walk and multiply by 2, which will be the number of lin. ft. of forms required. A sidewalk 4″ thick will require 2″x4″ lumber; 6″ thick, 2″x6″ lumber, etc.

The following table gives the number of feet of lumber, b.m. required to complete one sq. ft. of sidewalk 2′-0″ to 10′-0″ wide and 4″ to 8″ thick.

Number of Feet of Lumber, B. M. Required for One Sq. Ft. of 4″ Concrete Sidewalk

Width of Sidewalk

2 Feet	3 Feet	4 Feet	5 Feet	6 Feet	7 Feet	8 Feet	9 Feet	10 Feet
$\frac{9}{10}$-Ft.	$\frac{5}{8}$-Ft.	$\frac{1}{2}$-Ft.	$\frac{3}{8}$-Ft.	$\frac{3}{10}$-Ft.	$\frac{1}{4}$-Ft.	$\frac{1}{4}$-Ft.	$\frac{2}{10}$-Ft.	$\frac{2}{10}$-Ft.

Number of Feet of Lumber, B. M. Required for One Sq. Ft. of 6″ Concrete Sidewalk

Width of Sidewalk

2 Feet	3 Feet	4 Feet	5 Feet	6 Feet	7 Feet	8 Feet	9 Feet	10 Feet
1¼-Ft.	$\frac{7}{8}$-Ft.	$\frac{5}{8}$-Ft.	$\frac{1}{2}$-Ft.	$\frac{4}{10}$-Ft.	$\frac{3}{8}$-Ft.	$\frac{1}{3}$-Ft.	$\frac{3}{10}$-Ft.	$\frac{1}{4}$-Ft.

Number of Feet of Lumber, B. M. Required for One Sq. Ft. of 8″ Concrete Sidewalk

Width of Sidewalk

2 Feet	3 Feet	4 Feet	5 Feet	6 Feet	7 Feet	8 Feet	9 Feet	10 Feet
1⅔-Ft.	1⅛-Ft.	$\frac{7}{8}$-Ft.	$\frac{2}{3}$-Ft.	$\frac{6}{10}$-Ft.	$\frac{1}{2}$-Ft.	$\frac{4}{10}$-Ft.	$\frac{3}{8}$-Ft.	$\frac{1}{3}$-Ft.

The above quantities include necessary stakes for holding the forms in place. The cost of the forms may be obtained by computing the lumber cost as given above, and dividing by the number of times it may be used on the job.

Where concrete floors are placed on the ground it is customary to set wood screeds 6′-0″ to 8′-0″ on centers, so the floor will be level or have a uniform pitch. These screeds are removed as the work progresses and may be used many times. They are usually of 2″x4″ lumber, with stakes placed 3 to 4 ft. apart to hold the screeds in place. The lumber required will be the same as given for 4″ sidewalks and will vary with the spacing of the screeds.

Labor Placing Forms and Screeds for Sidewalks and Floors. On all classes of sidewalk work where the forms are either 4″, 6″ or 8″ wide, a cement mason should place and level 250 to 300 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

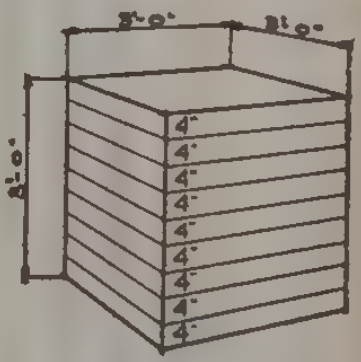
	Hours	Rate	Total	Rate	Total
Cement mason	3.0	$.....	$.....	$6.50	$19.50
Helper	1.5	.....	.....	5.00	7.50
Cost per 100 lin. ft.	4.5		$.....		$27.00
Cost per lin. ft.			.....		.27
Cost per lin. ft. walk			.....		.54

The above includes time removing forms.

When placing screeds for concrete floors on the ground, 2 cement masons working together should drive stakes, place and level 650 to 700 lin. ft. of screeds per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	2.4	$.....	$.....	$6.50	$15.60
Helper	1.2	.....	.....	5.00	6.00
Cost per 100 lin. ft.	3.6		$.....		$21.60
Cost per lin. ft.			.....		.216

Estimating the Quantity of Concrete Required for Floors and Walks.—To compute the number of sq. ft. of concrete floor or sidewalk that may be obtained from one cu. yd. of concrete (27 cu. ft.), laid out into a cube 3′-0″ wide, 3′-0″ thick and 3′-0″ high. The surface of this cube contains 9 sq. ft. and it is 36″ high.



If the rough concrete is 4″ thick, divide 36″ (the height of the cube) by 4″ (the thickness of the slab) and the result is 9; showing that it is possible to obtain 9 slabs, each containing 9 sq. ft. or 81 sq. ft. of 4″ floor or walk per cu. yd. of concrete.

Number of Sq. Ft. of Concrete Floor of Any Thickness Obtainable From One Cu. Yd. of Concrete

Thickness Inches	No. Sq. Ft.	Thickness Inches	No. Sq. Ft.	Thickness Inches	No. Sq. Ft.	Thickness Inches	No. Sq. Ft.
1	324	4	81	7	46	10	32
1¼	259	4¼	76	7¼	44	10¼	31
1½	216	4½	72	7½	43	10½	31
1¾	185	4¾	68	7¾	42	10¾	30
2	162	5	65	8	40	11	29½
2¼	144	5¼	62	8¼	39	11¼	29
2½	130	5½	59	8½	38	11½	28
2¾	118	5¾	56	8¾	37	11¾	27½
3	108	6	54	9	36	12	27
3¼	100	6¼	52	9¼	35	12¼	26½
3½	93	6½	50	9½	34	12½	26
3¾	86	6¾	48	9¾	33	12¾	25½

Materials Required for 1 Cu. Yd. of Concrete

This table is based on use of average wet sand and on 3- to 4-in. slump. Quantities will vary according to grading of aggregate and workability desired. No allowance has been made for waste. 1 sack cement = 1 cu. ft. 4 sacks cement = 1 bbl.

Size of Aggregate	Mixes				Yield of concrete per Sack of Cement Cu. Ft.	Materials per Cu. Yd. of Concrete			
	Mixing Water* per sack of Cement U.S. Gal.	Portland Cement Sacks	Aggregates			Water U.S. Gal.	Portland Cement Sacks	Aggregates	
			Sand Cu. Ft.	Gravel or Crushed Stone Cu. Ft.				Sand Cu. Yd.	Gravel or Crushed Stone Cu. Yd.
Maximum size ¾ in.	5	1	2.50	2.75	4.3	31	6.25	0.58	0.64
Maximum size 1 in.	5	1	2.25	3.00	4.5	30	6.00	0.50	0.67
Maximum size 1½ in.	5	1	2.25	3.50	4.7	29	5.75	0.48	0.75

*Based on 6 gal. of water per sack of cement including water contained in average wet sand.

Materials Required for 100 Sq. Ft. of Surface Area for Various Thicknesses of Concrete*

Thickness In.	Quantity of Concrete Cu. Yd.	Mixes								
		1:2½:2¾			1:2¼:3			1:2¼:3½		
		Cement Sacks	Aggregate		Cement Sacks	Aggregate		Cement Sack	Aggregate	
			Sand Cu. Yd.	Gravel or Crushed Stone Cu. Yd.		Sand Cu. Yd.	Gravel or Crushed Stone Cu. Yd.		Sand Cu. Yd.	Gravel or Crushed Stone Cu. Yd.
3	0.93	5.8	0.54	0.60	5.6	0.47	0.62	5.4	0.45	0.70
4	1.23	7.7	0.71	0.79	7.4	0.61	0.82	7.1	0.59	0.92
5	1.54	9.6	0.89	0.99	9.2	0.77	1.03	8.9	0.74	1.16
6	1.85	11.6	1.07	1.18	11.1	0.93	1.24	10.6	0.89	1.39
8	2.46	15.4	1.43	1.57	14.8	1.23	1.65	14.1	1.18	1.85
10	3.08	19.3	1.79	1.97	18.5	1.54	2.06	17.7	1.48	2.31
12	3.70	23.1	2.14	2.37	22.2	1.85	2.48	21.3	1.78	2.78

No allowance has been made for waste.

*100 sq. ft. of portland cement plaster ½ in. thick requires 1.6 sacks of cement and 0.15 cu. yd. of sand.

Mixing and Placing Concrete for Floors and Walks

Mixing Concrete By Hand.—In these days of high labor costs, concrete is seldom, if ever, mixed by hand but is usually mixed in a small mixer or ready-mix concrete is used and discharged direct into the forms or onto the floor.

However, for that one in a million job, here is some data on hand mixing, if you can find the men who will work that hard.

As with other classes of concrete work, the cost of mixing and placing the concrete will depend upon the number of times it is turned on the board and the method used in mixing and placing; but on the smaller jobs it will require 3½ to 4 hrs. labor time to mix and place one cu. yd. of concrete, as this class of work does not proceed as fast as foundation work.

On work of this kind, the gang usually consists of 5 or 6 men, so it is not possible for one man to work at the same class of work all day, but must alternate between wheeling sand, gravel, cement, and mixing concrete, as the job may require.

Five men working together should handle all materials, mix, place and tamp 20 to 24 batches (½-cu. yd. each) or 10 to 12 cu. yds. per 8-hr. day, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	3.33	$.....	$.....	$5.00	$16.65

Labor Mixing and Placing Concrete for Floors and Walks Using a Small Mixer.—A small concrete mixer of ½ or 1 sack (3½-S or 6-S) capacity is ordinarily used for floor and sidewalk work.

Where possible to use a full gang of men and keep the mixer in operation steadily, a mixer should discharge a batch every 2 minutes, but as in all other kinds of construction work there are always delays, such as engine adjustments, repairing mixer, delays caused by non-delivery of sand, gravel or cement, moving and placing runways, cleaning concrete barrows, etc., so the average for a job will be about 20 to 25 batches an hr. or 160 to 200 batches per 8-hr. day.

On the above basis, using either a 3½-S or 6-S concrete mixer, the labor cost per cu. yd. should run as follows:

	Hours	Rate	Total	Rate	Total
Labor	2.5	$.....	$.....	$5.00	$12.50

Using a larger mixer will increase the output but the labor cost will increase in direct proportion. Many of the largest contractors have found that a one sack mixer is the most economical unit for floor and sidewalk work.

Labor Mixing and Placing Concrete for Floors Using a 28-S Mixer and Batched Material.—On large floors, where 100 or more cu. yds. of concrete are required, a 28-S mixer fed by batch trucks may be used to advantage.

Under the above conditions a crew of 14 or 15 laborers, using buggies to wheel the concrete, should place 20 to 25 batches (1 cu. yd. each) per hr. at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.67	$.....	$.....	$5.00	$3.35
Mixer engineer	.05	.....	.....	6.00	.30
Cost per cu. yd.	.72		$.....		$3.65

With the same conditions as above except using power buggies instead of hand wheeled buggies a crew of 10 or 11 men should do the same amount of work at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.36	$.....	$.....	$5.00	$1.80
Power buggy operator	.09	.....	.....	5.00	.45
Mixer engineer	.05	.....	.....	6.00	.30
Cost per cu. yd.	.50		$.....		$2.55

Labor Placing Ready-Mixed Concrete for Floors.—In order to place ready-mixed concrete for floors with the most economy it is necessary to have a crew large enough to handle the concrete quickly to eliminate waiting time charges by the material company and the supply of mixed concrete must be steady and of sufficient quantity to keep the crew busy.

A crew of 14 or 15 laborers, using buggies to wheel concrete, should place 22 to 27 cu. yds. of ready-mixed concrete per hr. at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.6	$.....	$.....	$5.00	$3.00

If power buggies are used to transport ready-mixed concrete into place a crew of 10 or 11 men should handle 25 to 30 cu. yds. per hr. at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	0.36	$.....	$.....	$5.00	$1.80
Power buggy operator	.09	.....	.....	5.00	.45
Cost per cu. yd.	.45		$.....		$2.25

The above costs apply to floors containing 100 cu. yds. or more of concrete.

If, however, the floor is small, such as for a residence, small apartment building, etc., the work must be organized in a different manner. It is obvious that a job of this sort is too small to keep a number of ready-mix trucks busy and therefore no more than 1 or 2 trucks will serve the placing operation.

Assuming a floor pour serviced by one 5 cu. yd. capacity ready-mix truck, delivering one load of concrete per hr., a crew of 9 or 10 laborers should be kept reasonably busy and still handle the ready-mixed load of concrete fast enough to prevent waiting time penalties.

Based on the above conditions the labor cost of placing one cu. yd. of floor concrete will be as follows:

	Hours	Rate	Total	Rate	Total
Labor	1.8	$.....	$.....	$5.00	$9.00

Estimating the Labor Cost Per Sq. Ft. of Floor or Sidewalk. The labor costs given for mixing and placing rough concrete are based on a cu. yd. while floors and sidewalks are usually estimated by the sq. ft.

After the labor cost per cu. yd. has been obtained, divide this by the number of sq. ft. of floor obtainable from a cu. yd. of concrete and the result will be the labor cost per sq. ft. of floor. Example: Find the labor cost per sq. ft. of 4" floor. The table on previous pages shows that 81 sq. ft. of 4" floor can be obtained from one cu. yd. of concrete. If the labor cost is $10.00 per cu. yd. $10.00÷81=.123 or 12.3 cts. per sq. ft.

Cost of any other thickness is obtained in the same manner.

Materials Required for One Cu. Yd. of Plastic Cement Mortar Based on a Barrel of 3.8 Cu. Ft.

Proportions by Volume Cement Sand	Packed Cement. Sacks	Loose Sand. Cu. Yds.	Proportions by Volume Cement Sand	Packed Cement. Sacks	Loose Sand. Cu. Yds.
1:1	18.0	.70	1:2½	11.0	1.03
1:1½	15.2	.84	1:3	9.5	1.10
1:2	12.5	.95			

The above quantities are based on using loose damp sand containing 5 percent moisture and weighing 2,565 lbs. per cu. yd.

Number of Sq. Ft. of Cement Finish Topping Obtainable from One Cu. Yd. of Cement Mortar

Thickness in Inches	Square Feet	Square Yards	Thickness in Inches	Square Feet	Square Yards
⅛	2,592	288	⅞	370	41
¼	1,296	144	1	324	36
⅜	864	96	1¼	260	29
½	648	72	1½	216	24
⅝	518	57½	1¾	185	21
¾	432	48	2	162	18

Cost of One Cu. Yd. of Cement Mortar.—The following tables give the quantities of cement and sand required for one cu. yd. of cement mortar of the mixtures most commonly used for floors and sidewalks.

Cement Mortar in the Proportion of 1:1

	Rate	Total	Rate	Total
18 sacks portland cement	$.....	$.....	$1.80	$32.40
0.70 cu. yds. sand.....	.....	.....	4.00	2.80
Cost per cu. yd.....		$.....		$35.20

Cement Mortar in the Proportion of 1:1½

	Rate	Total	Rate	Total
15.2 sacks portland cement	$.....	$.....	$1.80	$27.36
0.84 cu. yds. sand.....	.....	.....	4.00	3.36
Cost per cu. yd.....		$.....		$30.72

Cement Mortar in the Proportion of 1:2

	Rate	Total	Rate	Total
12.5 sacks portland cement	$.....	$.....	$1.80	$22.50
0.95 cu. yds. sand.....	.....	.....	4.00	3.80
Cost per cu. yd.....		$.....		$26.30

Finishing Concrete Floors and Walks.—Concrete floors and walks can be finished in various ways. The concrete slab can be troweled smooth and left in its natural color or it may be given a linseed oil treatment or waxed and polished.

Another method is to use a dusted-on color mixture. After screeding the floor or walk to the proper level, a mixture of approximately 1 part portland cement and 1 to 1½ parts of sand and the required amount of pigment is immediately dusted uniformly over the fresh concrete. The dry mixture should be wood floated and worked into the concrete. Floating should be stopped as soon as the surface becomes wet, and resumed after the moisture disappears.

Where a separate finish topping is required on the floor, the surface of the structural base should be struck off reasonably level not less than 1-inch below the required finish grade.

As soon as the condition of the concrete base permits and before it has fully hardened, all dirt, laitance and loose aggregate shall be removed from the surface by means of a wire broom, which shall leave the coarse aggregate slightly exposed.

Just prior to placing the finish, the base slab shall be thoroughly cleaned by scrubbing.

The topping mixture shall be 1 part of portland cement; 1 part of fine aggregate (from No. 100 sieve to No. 4 sieve) and 2 parts of coarse aggregate (from No. 8 sieve to ⅜-in. sieve) by volume. This mix may be slightly varied, depending upon local conditions but in no case shall the volume of the coarse aggregate be less than 1½ times the volume of the fine.

Not more than 5 gals. of mixing water, including the moisture in the aggregates, shall be used for each sack of portland cement in the mixture.

After striking off the wearing course to the established grade, it shall be compacted by rolling or tamping and then floated with a wood float or power floating machine.

Floating shall be followed by steel troweling after the concrete has hardened sufficiently to prevent excess fine material from working to the surface.

Quantity of Cement, Fine and Coarse Aggregates Required for One Cu. Yd. of Concrete Topping

Proportions by Volume			Cement	Fine Aggreg.	Coarse Aggreg.
Cement	Fine	Coarse	Sacks	Cu. Yds.	Cu. Yds.
1	1	1½	11.4	0.42	0.63
1	1	2	10	0.37	0.74

Labor Finishing Cement Walks and Driveways.—The labor cost of finishing concrete walks and driveways will vary somewhat with the method used in finishing. If the rough concrete slab is floated and troweled without the use of a separate aggregate top, it will require a cement mason and helper, but if a separate finish topping is required, then the crew will consist of a cement mason, helper and a laborer to mix and wheel the finish topping for the finishing crew.

Concrete for sidewalks is usually of a very dry mix and stiff consistency so that the finish may be applied immediately after a section of the rough base has been laid. After allowing sufficient time for the topping to set, the finisher can return and trowel this section of the walk while the next section is being laid. Overtime may be materially reduced by using this method.

On nearly all classes of finish it requires 2 to 3 men in the gang. Where it is possible for the finisher to trowel and finish all day long, he will require a helper to assist in screeding and troweling the floor and a laborer to mix and deliver the finish topping.

If the sidewalk is blocked off into 4'-0" to 6'-0" squares, a finisher and helper should finish 600 to 700 sq. ft. per 8-hr. day. These quantities will often be exceeded but by making allowances for lost time, etc., it will prove a fair average because on nearly every job one-half the finisher's time is non-productive. It is often necessary to wait 2 to 4 hrs. after the rough concrete or finish topping has been placed before it sets sufficiently to be troweled. The brand of cement used will have considerable bearing on this as some cements set much more quickly than others.

Based on conditions as described above, the labor per 100 sq. ft. of finish should cost as follows:

	Hours	Rate	Total	Rate	Total
Cement mason	1.2	$.....	$.....	$6.50	$ 7.80
Helper	1.2	.....	.....	5.00	6.00
Labor mixing finish	1.2	.....	.....	5.00	6.00*
Cost per 100 sq. ft.	3.6		$.....		$19.80
Cost per sq. ft.			.....		.198

*Labor mixing topping may not be required full time.

If the rough concrete is floated and trowled without the use of a separate topping, omit time of "Labor mixing finish."

Labor Applying Cement Finish Top on Concrete Floors on the Ground.—The labor cost of placing finish top on concrete floors laid directly on the ground will run much the same as for sidewalk work, as it is possible to mix the concrete rather dry and either float and finish the rough concrete slab or place the separate finish immediately after the rough concrete has been placed over a sufficient area. However, there is some lost time due to waiting for the rough concrete or the finish topping to take its initial set.

Experience has proven that the strength of concrete is vitally affected by the amount of mixing water used and for this reason there is a tendency to use as little water as possible to obtain a workable consistency. This applies to both the rough concrete and the finish top, and the less water used, the sooner the finisher is able to start finishing.

Where possible to start finishing floors the first thing in the morning and continue all day, a finisher and helper should complete 100 to 125 sq. ft. of floor an hr. but instances of this kind are so rare as to be almost negligible.

On the average job it is necessary for the gang to place concrete for two or three hours in the morning before a sufficient area is covered to start finishing or to place the finish top. After the finish has been placed and leveled, it is necessary to wait from 1 to 3 hrs. until it sets sufficiently to allow the finisher to commence troweling. In this way practically half a day has been spent by the finisher without completing any floor.

Where the gang placing the rough concrete works until the regular quitting time, it will be necessary for the finishers and helpers to work far into the night to place the finish top.

While some cement finishers may finish 175 to 200 sq. ft. of floor an hr. under favorable conditions, the average will be 75 to 85 sq. ft. an hr. or 600 to 700 sq. ft. per 8-hr. day.

The labor cost per 100 sq. ft. should run as follows:

	Hours	Rate	Total	Rate	Total
Cement mason	1.2	$.....	$.....	$6.50	$ 7.80
Helper	1.2	.....	.....	5.00	6.00
Labor mixing finish	1.2	.....	.....	5.00	6.00
Cost per 100 sq. ft.	3.6		$.....		$19.80
Cost per sq. ft.					.198

*Labor mixing topping may not be required full time. Adjust to suit.

If the rough concrete slab is floated and troweled without the use of a separate topping, omit time of "Labor mixing finish."

Labor Applying Cement Finish Top on Reinforced Concrete Floors.—The cost of placing finish top on reinforced concrete floors is subject to wide fluctuations. One of the reasons is the custom of placing the rough concrete over as large an area as possible and then allowing the concrete to stand until the water disappears from the surface before starting finishing or placing the cement topping. This allows the finish top to take its initial set in the least possible time. However, the time required for cement to take its initial set depends upon the brand of cement used, as some cements are noted for being either "quick setting" or "slow setting."

The amount of water used in the concrete mix also has considerable bearing on the finishing cost because if "sloppy" concrete is used it requires much more time for the floor to set sufficiently to receive the finish top than if concrete of a rather "stiff" consistency is used.

Many architects and engineers specify the floor must be finished or the finish top must be applied and finished at the same time the rough concrete is placed, and in such instances it necessitates a large amount of overtime for finishers and helpers.

Where the gang places rough concrete right up until quitting time, it is a foregone conclusion that the finishers and helpers will have to work far into the night.

The item of overtime should be carefully considered by the estimator for as a usual thing the cement mason starts work when all other trades have quit for the day.

While under favorable conditions, some finishers and helpers may finish 175 to 200 sq. ft. of floor an hour on certain classes of work, the general average for a reinforced concrete job will vary from 70 to 80 sq. ft. an hr. or 560 to 640 sq. ft. per 8-hr. day. It will also require the time of a man mixing the finish topping and placing it on the floor ready for the finisher and helper, where a separate finish is required.

The labor costs given are for straight time but the estimator should bear in mind that overtime costs time and a half or double time.

The labor per 100 sq. ft. of floor should cost as follows:

	Hours	Rate	Total	Rate	Total
Cement mason	1.3	$.....	$.....	$6.50	$ 8.45
Helper	1.3	.....	.....	5.00	6.50
Labor mixing finish	1.3	.....	.....	5.00	6.50
Cost per 100 sq. ft.	3.9		$.....		$21.45
Cost per sq. ft.			.....		.215

If the rough concrete slab is floated and troweled without the use of a separate topping, omit time of "Labor mixing finish."

Finishing Concrete Floors by Machine.—During recent years rapid strides have been made in the finishing of concrete floors

Concrete Screeding Machine.

by power operated machines. These machines are used for screeding, floating and troweling the finish floor.

When placing concrete floors, walks and pavements on the ground, the wood or metal floor screeds are placed in the usual

manner and the concrete is struck off by using a power operated screeding machine, which makes 2½" transverse strokes on the header boards, leveling and compacting the mix. A steady pull forward by the operator, advances the machine at the rate of 10 ft. a minute or 600 lin. ft. per hour and will strike off a slab 6 to 20 feet in width. This machine costs about $430.00, while a smaller machine costs about $320.00.

A four man crew is usually required with the machine; two laborers spreading the concrete and two cement masons operating the screeding machine.

After the concrete slab has been screeded ready for troweling, allow sufficient time for the concrete to set hard enough to walk on before starting finishing.

For floating, the machine is equipped with 12 gage steel trowels, which revolve on a 46" diameter. It usually requires 3 cement masons; 1 finisher to operate the machine and 2 finishers touching up corners, columns, edging, jointing, etc. On a well prepared slab, one finishing crew can float 4,000 sq. ft. of floor an hr. but this is not usually maintained due to job delays, etc. This machine costs about $540.00.

A smaller finishing machine having a 34" diameter, costs about $430.00, and will float up to 3,000 sq. ft. of floor an hour under the same conditions as stated above.

A heavy 24" disc float costs about $500.00, while a 24" disc float equipped with complete finishing machine equipment and controls, including finishing tools, costs about $650.00.

After the floor has been floated, the heavy gauge steel floating trowels are removed and replaced with 17 gauge steel "finishing" trowels. The cement mason then guides the rotating, adjustable pitch trowels over the slab until a smooth, level surface is obtained.

Using the larger machines, and assuming a "four time over" was necessary to complete the job, it would require 4 hrs. of machine operation and assuming a ¾ to 1-hr. waiting period was necessary between each operation, it would require a total of 6¼ to 7 hrs. time to finish 4,000 sq. ft. of floor.

The labor screeding 4,000 sq. ft. of floor should cost as follows:

Rodding Floor	Hours	Rate	Total	Rate	Total
Cement mason	2	$.....	$.....	$6.50	$13.00
Labor	2	.....	.....	5.00	10.00
Machine charge	1	.....	.....	3.00	3.00
Cost of screeding 4,000 sq. ft.	5		$.....		$26.00
Cost per sq. ft.....			.....		.0065

The above does not include time mixing concrete or cement finish topping and placing on floor, ready for screeding.

After the floor has been screeded, the labor floating and troweling (4 times over), 4,000 sq. ft. of cement finish floor should cost as follows:

	Hours	Rate	Total	Rate	Total
Cement mason operator..	8	$.....	$.....	$6.50	$ 52.00
Cement masons	16	.....	.....	6.50	104.00
Machine charge	8	.....	.....	3.00	24.00
Labor cost 4,000 sq. ft...	32		$.....		$180.00
Cost per sq. ft.....			.....		.045

Extra trowels for the above machines cost from $20.00 to $25.00 per set for the float blades and $12.00 to $18.00 per set for the finishing blades.

Cost of 100 Sq. Ft. of 4½" Concrete Sidewalk

Based on walk 4'-0" x 25'-0" and 4½" thick, consisting of 4" of rough concrete and ½" top, with 6" of grading necessary and a 6" bed of cinders under concrete.

	Hours	Rate	Total	Rate	Total
Labor excavating and grading	2.50	$.....	$.....	$5.00	$ 12.50
Labor spreading and tamping cinders	2.28	.....	.....	5.00	11.40
65 cu. ft. cinders.....		.....	.....	.07	4.55
50 ft. b.m., 2"x4" forms...		.....	.....	.06*	3.00*
Cem. mason placing forms	1.50	.....	.....	6.50	9.75
Helper	.75	.....	.....	5.00	3.75
Labor mixing and placing 100 sq. ft. (1¼ cu. yds.)	3.10	.....	.....	5.00	16.50
33 cu. ft. concrete.....		.....	.....	.60	19.80
Cement mason	1.20	.....	.....	6.50	7.80
Helper	1.20	.....	.....	5.00	6.00
Labor mixing finish top...	1.20	.....	.....	5.00	6.00
4.25 cu. ft. cement mortar		.....	.....	.80	3.40
Cost per 100 sq. ft. 13.73			$.....		$104.45
Cost per sq. ft.....					1.045
Material cost per sq. ft....			.....		.308
Labor cost per sq. ft.....			.....		.637

*Based on 3 uses of lumber.

If the concrete slab is floated and troweled without the use of a separate topping, add 4¼ cu. ft. concrete and omit cost of cement mortar for topping, also labor mixing finish top.

Cost of 100 Sq. Ft. of 5″ Concrete Floor

Based on floor 5″ thick, consisting of 4¼″ of rough concrete and ¾″ top 1:2, with 6″ of grading necessary and 5″ of cinders under the floor.

	Hours	Rate	Total	Rate	Total
Labor excavating and grading	2.50	$.....	$.....	$5.00	$12.50
Labor spreading and tamping cinders	1.93	.....	.....	5.00	9.65
Cement mason placing screeds	0.50	.....	.....	6.50	3.25
40 ft. b.m., 2″x4″ screeds		.....	.....	.06*	2.40*
Helper	0.25	.....	.....	5.00	1.25
55 cu. ft. cinders		.....	.....	.07	3.85
Labor mixing and placing 100 sq. ft. (1½ cu. yds.) rough concrete	3.30	.....	.....	5.00	16.50
36 cu. ft. concrete		.....	.....	.60	21.60
Cement mason	1.20	.....	.....	6.50	7.80
Helper	1.20	.....	.....	5.00	6.00
Labor mixing finish top	1.20	.....	.....	5.00	6.00
6.25 cu. ft. cement mortar		.....	.....	.80	5.00
Cost per 100 sq. ft.	12.08		$.....		$95.80
Cost per sq. ft.			.....		.958
Material cost per sq. ft.			.....		.328
Labor cost per sq. ft.			.....		.630

*Based on 3 uses of lumber.

If the concrete slab is floated and troweled without the use of a separate topping, add 6.25 cu. ft. concrete and omit cost of cement mortar for topping, also labor mixing finish top.

Floors of any other thickness should be estimated in the same manner.

Color for Concrete Floors

Color for concrete is used for sidwalks, driveways, porches, tennis courts, floors, etc., the desired color being mixed into the cement topping which should be either ½, ¾ or 1-in. thick, depending upon service requirements.

The amount required varies with the different manufacturers but the following proportions generally will produce good results.

Pigments for COLORED CONCRETE Floors

Color desired	Commercial names of colors for use with cement	Approximate quantities required — lb. per sack of cement	
		Light shade	Medium shade
Greys, blue-black and black	Germantown lampblack*	½	1
	or carbon black* or	½	1
	black oxide of manganese*	1	2
	or mineral black	1	2
Blue	Ultramarine blue	5	9
Brownish red to dull brick red	Red oxide of iron	5	9
Bright red to vermilion	Mineral turkey red	5	9
Red sandstone to purplish red	Indian red	5	9
Brown to reddish-brown	Metallic brown (oxide)	5	9
Buff, colonial tint and yellow	Yellow ochre or	5	9
	yellow oxide	2	4
Green	Chromium oxide or	5	9
	greenish blue ultramarine	6	

*Only first-quality lampblack should be used. Carbon black is light in weight and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 lb. of oxide for each sack of cement.

Approximate quantities required for 100 sq. ft. of floor:

	½" Top	¾" Top	1" Top
Gray portland cement	1.5 sacks	2.25 sacks	3.00 sacks
Clean sand	150 lbs.	225 lbs.	300 lbs.
Coarse aggregate, ⅜" max. size	263 lbs.	394 lbs.	525 lbs.
Conc. cement color*	13.5 lbs.	20.3 lbs.	27 lbs.

For 1" topping, use not more than 5 gal. mixing water, including water in aggregates. Smaller mixes in proportion.

Sand and coarse aggregate based on 100 lbs. per cu. ft.

Colors and Approximate Prices of Concentrated Cement Colors

Color	Price per Lb.	Cost per 100 Sq. Ft. ½" Thick	¾" Thick	1" Thick
Bright Red	$0.29	$ 3.92	$ 5.98	$ 7.84
Medium Red	.25	3.38	5.07	6.76
Deep Red	.28	3.78	5.68	5.56
Bright Yellow	.26	3.51	5.28	7.02
Orange Buff	.25	3.38	5.07	6.76
Terra Cotta	.23	3.11	4.67	6.22
Bright Blue	.41	5.54	8.33	11.08
Rich Brown	.35	4.72	7.11	9.44
Light Brown	.22	2.97	4.47	5.94
Purple	.49	6.62	9.95	13.24
Jet Black	.35	4.72	7.11	9.44
Bright Green	.56	7.56	11.38	15.12

Colors are usually packed in 9-lb. bags, 100-lb. drums and barrels.

When mixed in the proportions of 1:2, use 9 lbs. of cement color to each bag of portland cement used in the topping.

It is advisable to establish the mixture from samples made under job conditions and allowed to dry. Careful measurement of every ingredient, including water, in each batch is essential to insure uniformity of color.

Final troweling should be done after the concrete has stiffened, as this assures a smooth, polished finish. Integral waterproofing or hardener can be added to mix materials, also polishing or a surface treatment can be applied, if desired.

Colorundum* Surface Colorant and Hardener for Concrete.—Colorundum is a ready-to-use powder containing non-crushable hardeners, dispersing agents and cementitious binders. It provides a durable, integral concrete color that does not wear off as paint and ordinary surface coatings do. When Colorundum is dusted on and trowelled into freshly poured concrete it produces bright, decorative surfaces with dense coloration. Hard, abrasion resistant surfaces with long life.

Colorundum is for interior and exterior concrete floors and sidewalks. The hard wearing, highly decorative finish of Colorundum floors makes them ideal for use in factories, schools, hospitals, office buildings, showrooms, supermarkets, stores or any public building. Colorundum may be used inside or outside on

*W. R. Grace Co. A. C. Horn Products.

traffic areas such as sidewalks, ramps, patios, breezeways, terraces, sun decks and playgrounds. For best results, the slump of concrete monolithic slabs should not exceed 2½" and for toppings 3". Excess water causes laitance to rise to the surface, producing discoloration, and also causes separation which delays the finishing operation.

Do not use air entraining agents, or other admixtures in the topping mix.

The topping mix recommended for the best results is 1:1:2 (one part cement, one part sand and two parts 1/4" to 5/16" angular aggregate).

Thoroughly clean the rough base slab surface. Saturate concrete with water at least 4 to 6 hours. Brook off excess pools and scrub in slush (bonding) coat, just ahead of the pours. Mix a slush coat of cement and water, or cement and Vibro-Foil (equal parts by weight) and water. The slush coat should be sufficiently thin in consistency so it can be well scrubbed into the rough surface and edges to assure uniform bond of the topping. If slush coat contains Vibro-Foil, it should be well brushed out and not allowed to lie in low spots.

Pour the topping, tamp and strike off to finish floor level. The topping should be as stiff as can be handled. Use mixtures and construction methods that prevent segregation which results in free water and fine materials on the top surface.

When excess water disappears and the topping will hold up knee boards, uniformly dust on 2/3 of specified amount of Colorundum per 100 sq. ft. of surface.

After spreading, allow the dry material to wet up. It should then be wood floated and worked into the slab. The first floating should be discontinued as soon as the surface becomes wet. Floating should be resumed when surface moisture has disappeared. Do not steel trowel. Immediately apply to second coat of remaining 1/3 of the specified amount per 100 sq. ft. and thoroughly wood float. (For heavy duty finish, the quantity of Colorundum may be increased for the second dust coat.) Apply Colorundum exactly as it comes from the container. Do not mix with cement or concrete.

Steel trowel to an even plane free from surface marks and voids. When the floor has obtained its initial set, give it a final steel trowel burnishing. Leave exterior areas, such as sidewalks, under wood float finish after the trowelling.

To cure, use an approved curing and sealing compound according to manufacturers' instructions or cover the surface approximately 4 hours after finish trowelling with a tough, non-staining,

moisture-tight kraft paper butted and taped securely. This seals against evaporation of the water so vitally necessary to hydrate the cement, thereby developing optimum strength and density throughout the mass. It also protects the colored surface against spillages.

Use approximately 30 lbs. per 100 sq. ft. for normal traffic areas. For areas subject to extra heavy traffic, the quantity of Colorundum may be increased proportionately.

Price per pound in 60-lb. pails: Tile red, terra cotta and French grey—35 cts. per lb. Egyptian green—48 cts. per lb. Other colors are available in minimum of 500 lb. orders.

Staybrite* Integral Color for Concrete and Mortar.—Staybrite dry colors are finely ground, carefully prepared pigment concentrations of unusually high tinctural strength. Only commercially pure metallic pigments are used which will not fade or reduce the strength of cement mixes. Staybrite is limeproof, alkali resisting and sun fast, providing strong, intense, durable shades of color.

It is for integral coloring of concrete mixes to be used in floors, walls or sidewalks. Mortar mixes for brick, block or stone work may be colored to match or to contrast with masonry units by adding Staybrite. These non-fading colors enhance the beauty of all concrete and mortar surfaces, indoors and outdoors.

Staybrite is supplied in premeasured quantities, packaged in polyethylene transparent bags which are heat-sealed to prevent seepage. Each package contains the exact amount of color required per bag of cement. Factory packaging insures uniformity of color since variation due to improper weighing at the job is eliminated. Staybrite is added to dry components, mixing thoroughly to an even color and brought to proper workability with the addition of the gauging water.

Amounts of sand, cement and lime must be carefully measured by weight to maintain uniformity of color. Do not use too wet a mix or over-trowel which brings considerable laitance to the surface, thus masking the color. Concrete should be stiff. Floating and trowelling should follow a uniform direction and be stopped as soon as surface wets up. In masonry mortar containing hydrated lime, an additional 4 lbs. of color may be safely added for each bag of lime.

Suggested use per sack of cement: Tile red, 8 lbs., 25 cts. per lb.; Persian yellow, 5 lbs., 45 cts. per lb.; Alaskan brown, 5 lbs., 33 cts. per lb.; Egyptian green, 5 lbs., $1.30 per lb.; linoleum brown, 5 lbs. 33 cts. per lb.; chocolate, 8 lbs., 45 cts. per lb. and nonmetallic black, $1.25 per lb.

*W. R. Grace Co. A. C. Horn Products.

Resurfacing Old Concrete Floors and Patching Floors Having Holes, Ruts and Breaks

Many concrete floors subject to trucking and heavy service become full of holes and ruts and require patching or a complete new topping. A new concrete topping is expensive because of the labor involved in removing the old floor and the additional thickness required to bond the new concrete slab to the old base.

Stonhard Resurfacer* is a material having a composition mastic base and bonds permanently to the old surface. It is mixed with sand and cement and applied directly over the old wood or concrete floor or used to fill holes and ruts where a complete overlay is unnecessary.

Clean the old floors to remove all loose particles, grease and grime. Oakite or other caustic solutions may be used for cleaning the floors of grease, etc.

The standard application is ½" thick and it can be feather-edged wherever desired. Where the floor is subject to hand trucking, ¼" crushed stone, trap rock, grits or pebbles should be mixed with the sand and resurfacing materials but if subject only to power trucking, sand and cement only is mixed with the resurfacing materials.

Stonhard Resurfacer will harden ready for use in about 36 hours but if the floor must be ready for service in 16 to 20 hours, "Resmix" is used instead of portland cement to hasten the hardening action.

A 3-man crew, consisting of foreman, cement mason and helper should place 550 to 650 sq. ft. of floor per 8-hr. day.

Materials and Labor Required for 100 Sq. Ft. of Stonhard Resurfacer ½-in. Thick Applied Over Old Concrete Floors

Material and Labor per 100 Sq. Ft. Floor	Floors for Power Trucking	Heavy Loads on Hand Trucks
Stonhard Resurfacer	80 lbs.	72 lbs.
Stonhard Primer	7 lbs.	7 lbs.
Portland cement	1 sack	1 sack
Sand	2 cu. ft.	2 cu. ft.
¼" crushed stone		2 cu. ft.
Foreman	1.33 hrs.	1.33 hrs.
Cement finisher	1.33 hrs.	1.33 hrs.
Helper	1.33 hrs.	1.33 hrs.

*Stonhard Company.

The cost of Stonhard Resurfacer and Primer varies according to quantity. Approximate price of Resurfacer in 460-lb. drums and Primer in 84-lb. companion units, 25 cts. per lb.; Resurfacer in 250-lb. drums and Primer in 42-lb. units, 26½ cts. per lb.

When Stonhard Resurfacer is applied over old wood floors, cover the old floor with ¾ or 1-in. mesh poultry netting. Add 10 per cent to material quantities given for concrete floors. Labor costs will also be about 20 percent higher.

Quick Hardening Stonhard Floor Resurfacer.—Where it is necessary to have floors ready for service in 16 to 20 hours, use the following proportions of materials instead of those given above. Labor costs the same in both instances.

Materials per 100 Sq. Ft. of Floor	Floors for Power Trucking	Heavy Loads on Hand Trucks
Stonhard Resurfacer	60 lbs.	54 lbs.
Stonhard Primer	7 lbs.	7 lbs.
Resmix (used instead of portland cement)		
$0.11 lb.	100 lbs.	95 lbs.
Sand	2 cu. ft.	2 cu. ft.
¼" crushed stone		2 cu. ft.

Stonhard resurfacer and primer are also suitable for patching and resurfacing work on exterior surfaces, such as platforms, steps, sidewalks and driveways.

Mulsomastic* Flooring.—A cold applied mastic flooring made by mixing fibrated Mulsomastic with sand, gravel and portland cement in proportions as recommended.

Often used over old concrete or wood floors as a resurfacing or for patching. Mulsomastic Primer must be used for a bond coat in all instances.

Under ordinary conditions the following materials are required for 100 sq. ft. of floor, ½-in. thick:

	Quan. per 100 Sq. Ft.	Approx. Price
Mulsomastic Primer	1½ gal.	$1.40 gal.
Mulsomastic Fibrated	8–12 gal.	1.40 gal.

*The Tremco Manufacturing Co., Cleveland, Ohio.

Vibro-Foil* Non-Shrink Grouting Compound.—Vibro-Foil is a compound of iron particles, hardening and dispersing agents, binders and oxidizing agents. When mixed with cement mortar and concrete, it produces a mass which has controlled expansion to overcome the inherent shrinkage in cementitious mixtures. The metallic aggregate also provides a ductile surface with the "give and take" properties concrete must have to absorb the vibration of machinery, equipment and columns.

Vibro-Foil is used wherever non-shrink concrete is mandatory: setting machinery on concrete foundations; full bearing surface grouting for building columns; and grouting anchor bolts, floor grids, steel sash and jambs.

Grouting should be continuous once it has started. Do not mix more grout at one time than can be rodded and placed in a period of 20 minutes. Add only enough water to make mix placeable—avoid an excess of water.

Anchor forms securely to prevent movement during placing and curing. Intersection of form and base slab can be filled with a mix of equal parts of cement and sand before placing grout. Be sure to allow adequate clearance between forms and base plate.

Remove waste material and water from anchor bolt holes. All oil, grease and paint in contact with grout should be thoroughly removed from base plates before grouting.

Clean slab or foundation with liberal quantities of water. If oil is present, use Horn Grease and Stain Remover to clean slab. Slab should be moist to assure easy flow of grout and to prevent rapid drying out. Avoid placing while excess water is present on the foundation slab.

It is not necessary to remove shims or loosen leveling screws when using Vibro-Foil.

Lengths of chain (up to 1" link) laid in the form before placing grout will assist in compacting the grout and eliminating air pockets. Chain should be worked in short, quick strokes and removed before initial set occurs.

Whenever possible, Vibro-Foil should be placed from one end or side only to avoid excessive air-entrapment and to assure compactness of grout.

It is important to place grout quickly and continuously to avoid all effects of overworking, resulting in segregation, bleeding and break-down of initial set. Under no circumstances should Vibro-Foil be retempered by introducing additional water after it has taken its initial set. Keep containers closed when not in use.

*W. R. Grace Co. A. C. Horn Products.

Vibro-Foil is grey or black in color and is packaged in 100-lb. containers. Cost of Vibro-Foil is about 15 cts. per lb.

Lightweight Concrete Floor Fill

Concrete made of lightweight aggregate, such as cinders, slag, Haydite, pumice, vermiculite and other lightweight aggregates are often used for floor fill under marble and tile floors, between wood floor sleepers, screeds, etc.

The labor cost of placing concrete floor fill runs considerably higher than for ordinary concrete because the fill is usually only 2″ or 3″ thick, which necessitates covering a large floor area to place a comparatively small amount of concrete. In many instances it is necessary to pump or hoist the concrete to the upper floors in wheelbarrows or concrete buggies and then wheel it to the different parts of the building where it is to be used.

When placing concrete fill between wood floor sleepers or screeds, it is important that every precaution be taken to prevent the sleepers from being knocked out of level when wheeling over them. As this work is usually done after the partitions and rough door bucks are in place, care must be used to prevent knocking wheelbarrows into door bucks and partitions.

When placing concrete floor fill, it is not advisable to use a large mixer because of the necessity of covering a large floor area to place a small amount of concrete. It usually requires considerable leveling and tamping, making it impractical to handle the concrete in large quantities. A concrete mixer of 1 or 2 sacks capacity is best adapted for this class of work.

Mixing and Placing Concrete Floor Fill.—Because of the additional labor required for spreading, grading and tamping concrete floor fill, the cu. yd. labor costs run higher than for foundation or sidewalk work.

There is also more labor required wheeling concrete from the mixer to the hoist and from the hoist to place of deposit, as floor fill is usually placed after the structural portions of the building have been completed, and it is not possible to carry on the work with as much speed as before door bucks and partitions were erected.

A crew of 13 men with a 6-S mixer should handle materials, mix and wheel into place 15 to 20 batches (containing 6 to 7 cu. ft. each) or 3½ to 5 cu. yds. of concrete an hour with the men distributed as follows: 2 men wheeling coarse aggregate from stock pile to mixer; 2 men wheeling sand and cement to mixer; 1 man attending mixer; 3 men wheeling concrete from mixer to hoist; 3 men wheeling concrete from hoist to place of deposit; 2 men dumping barrows and spreading concrete.

The labor per cu. yd. should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	3.00	$.....	$.....	$5.00	$15.00
Hoisting engineer	0.35	.....	.....	6.00	2.10
Cost per cu. yd.	3.35		$.....		$17.10

If union rules require a mixer engineer, deduct 0.35-hr. labor time and add 0.35-hr. engineer time per cu. yd.

If concrete is discharged from mixer directly into a hoist concrete bucket and wheeled from a floor hopper to place of deposit, deduct 0.50-hr. labor time.

If no hoisting is required, deduct 0.70-hr. labor time and omit hoisting engineer.

For concrete roof fill on flat roofs, deduct about 10 percent from the above costs. On pitch or gable roofs, add 25 to 50 percent, depending on steepness of slope, accessibility, etc.

After the cubic yard cost has been computed, to obtain the sq. ft. cost, divide the cu. yd. cost by the number of sq. ft. of fill obtainable from one cu. yd. and the result will be the labor cost per sq. ft. of fill. Example: Find the sq. ft. labor cost of 3″ floor fill with the cu. yd. cost $17.10. The table on the previous pages gives 108 sq. ft. of 3″ fill obtainable from one cu. yd. $17.10÷108= .158 or 15.8 cts. per sq. ft.

To the above costs must be added the cost of setting screeds and all finishing operations as given on the following pages.

Finishing Lightweight Concrete Floor and Roof Fill

All concrete floor and roof fills require some finishing labor, if only setting of screeds and striking off fill at screed height.

Where fill is placed between wood sleepers, screeds are not required but the fill must be struck off and darbied so that no part of it is higher than the top of the sleepers. In addition, the fill should be spaded along both sides of each sleeper so that good anchorage is obtained.

For 2″ thick concrete fill between wood floor sleepers, 2 cement masons working with a helper should strike off and darby 5,000 to 6,000 sq. ft. per 8-hr. day or about all the fill a small-mixer crew can mix and place in an 8-hr. day. The labor per 100 sq. ft. should cost as follows:

	Hours	Rate	Total	Rate	Total
Cement mason	0.30	$.....	$.....	$6.50	$1.97
Helper	0.15	.....	.....	5.00	.75
Cost per 100 sq. ft.	0.45		$.....		$2.70
Cost per sq. ft.					.027

Finishing Concrete Floor Fill Under Resilient Flooring.— Where concrete fill is used as a base for cork, asphalt, vinyl, rubber or linoleum floor covering, it is necessary to obtain a

smooth level finish on the concrete to receive the finish floor material or all irregularities will show through on the finished surface.

To obtain the required degree of smoothness, screeds must be placed 4'-0" to 6'-0" on centers and concrete fill must be struck off, darbied, floated and in most cases it will be necesary to trowel the floor at least once over.

If the fill is not over 2" thick, 2 cement masons working together with a helper should place screeds, strike off, darby, float and trowel once over 800 to 1,000 sq. ft. of floor per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	1.8	$.....	$.....	$6.50	$11.70
Helper	0.9	.....	.....	5.00	4.50
Cost per 100 sq. ft.	2.7		$.....		$16.20
Cost per sq. ft.			.....		.162

Finishing Concrete Roof Fill.—Concrete fill for flat roofs are usually struck off, darbied and floated. If fill is not over 2" to 3" thick, 2 cement masons with a helper should place screeds, strike off, darby and float 1,500 to 1,700 sq. ft. of roof fill per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	1.0	$.....	$.....	$6.50	$6.50
Helper	0.5	.....	.....	5.00	2.50
Cost per 100 sq. ft.	1.5		$.....		$9.00
Cost per sq. ft.			.....		.09

Where concrete fill is placed on pitch or gable roofs, finishing is more difficult, screeds must be set closer together to help hold the fill from sliding down the slope and an additional helper is usually required. On work of this type, 2 cement masons and 2 helpers should place screeds, strike off, darby and float 900 to 1,000 sq. ft. of fill per 8-hr day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	1.60	$.....	$.....	$6.50	$10.40
Helper	1.60	.....	.....	5.00	8.00
Cost per 100 sq. ft.	3.20		$.....		$18.40
Cost per sq. ft.			.....		.184

Concrete Roof Saddles.—The labor for placing and finishing roof saddles is usually estimated together as one item on a square foot basis. Since the material required is generally small, the concrete is either mixed in a 6-S concrete mixer, a paddle type mortar mixer or may even be hoe-mixed in a mortar box or wheelbarrow. Either method will cost about the same.

If the saddles do not average more than 3" thick, a crew of

2 cement masons and 4 laborers should set screeds, mix, place and finish 600 to 700 sq. ft. of roof saddles per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	2.5	$.....	$.....	$6.50	$16.25
Labor	5.0	.....	.....	5.00	25.00
Hoisting engineer*	0.3	.....	.....	6.00	1.80
Cost per 100 sq. ft.	7.8		$.....		$43.05
Cost per sq. ft.			.....		.431

*Deduct if not required.

Concrete Cants.—Concrete cants, placed at the intersection of roof surfaces with all vertical surfaces to ease the upturn of roof flashing, are estimated by the lineal foot.

Concrete cants vary from 3" x 3" to 6" x 6" and in special instances even larger, but the majority will average about 4" x 4". Where runs are straight and long, a cement mason and a helper should complete 150 to 175 lin. ft. of 4" x 4" concrete cant per 8-hr. day at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	5	$.....	$.....	$6.50	$32.50
Helper	5	.....	.....	5.00	25.00
Cost per 100 lin. ft.	10		$.....		$57.50
Cost per lin. ft.			.....		.575

If cant runs are short and cut up, add 15 to 25 percent to the above costs.

Metal Floor Clips.—Metal floor clips inserted in the rough concrete floor are used to hold the wood floor screeds or sleepers in place, without the use of concrete fill. The clips are usually spaced 16" on centers with nails driven through the clips into the sides of the screeds.

The wood screeds may be either 2"x2", 2"x3" or 2"x4" and the clips cost as follows: 2"x2", $56.00 per 1,000; 2"x3", $59.00 per 1,000; and 2"x4", $62.00 per 1,000.

Material Required for One Cu. Yd. of Cinder or Slag Concrete

1:3:6 Cinder or Slag Concrete

	Rate	Total	Rate	Total
1 bbl. portland cement	$.....	$.....	$7.20	$ 7.20
0.46 cu. yds. sand	.....	.....	4.00	1.84
0.92 cu. yds. cinders or slag	.....	.....	1.90	1.75
Cost per cu. yd.		$.....		$10.79

1:4:7 Cinder or Slag Concrete

	Rate	Total	Rate	Total
0.83 bbls. portland cement	$.....	$.....	$7.20	$ 5.98
0.51 cu. yds. sand	.....	.....	4.00	2.04
0.89 cu. yds. cinders or slag	.....	.....	1.90	1.69
Cost per cu. yd.		$.....		$ 9.71

1:4:8 Cinder or Slag Concrete

	Rate	Total	Rate	Total
0.77 bbls. portland cement.	$.....	$.....	$7.20	$5.54
0.47 cu. yds. sand	.....	.....	4.00	1.88
0.93 cu.yds.cinders or slag	.....	.....	1.90	1.77
Cost per cu. yd.		$.....		$9.19

Number of Sq. Ft. of Floor Fill of Various Thicknesses Obtainable From One Cu. Yd. of Concrete

Thickness of Floor Fill in Inches

1"	1¼"	1½"	1¾"	2"	2¼"	2½"	2¾"	3"	3¼"	3½"	3¾"	4"
324	261	216	180	162	144	126	117	108	99	92	86	81

To obtain the sq. ft. cost of concrete floor fill of any thickness, divide the cu. yd. cost by the number of sq. ft. obtainable from one cu. yd. as given in the above table. The result will be the cost per sq. ft. Example: Find the cost of one sq. ft. of 1:3:6 concrete floor fill 2" thick, with concrete at $10.79 per cu. yd. $10.79÷162=.066 or 6.6 cts. per sq. ft. The cost of any other thickness is obtained in the same manner.

Lightweight Concrete, Insulating Concrete of Pumice, Perlite, Vermiculite and Other Lightweight Aggregates

Lightweight concrete of crushed slag, foamed slag, haydite, pumice, diatomite, perlite and vermiculite are used for floor and roof fill, structural roofs, radiant heat floor panels, floors in cold storage rooms, cattle barns, hog houses, poultry houses, etc.

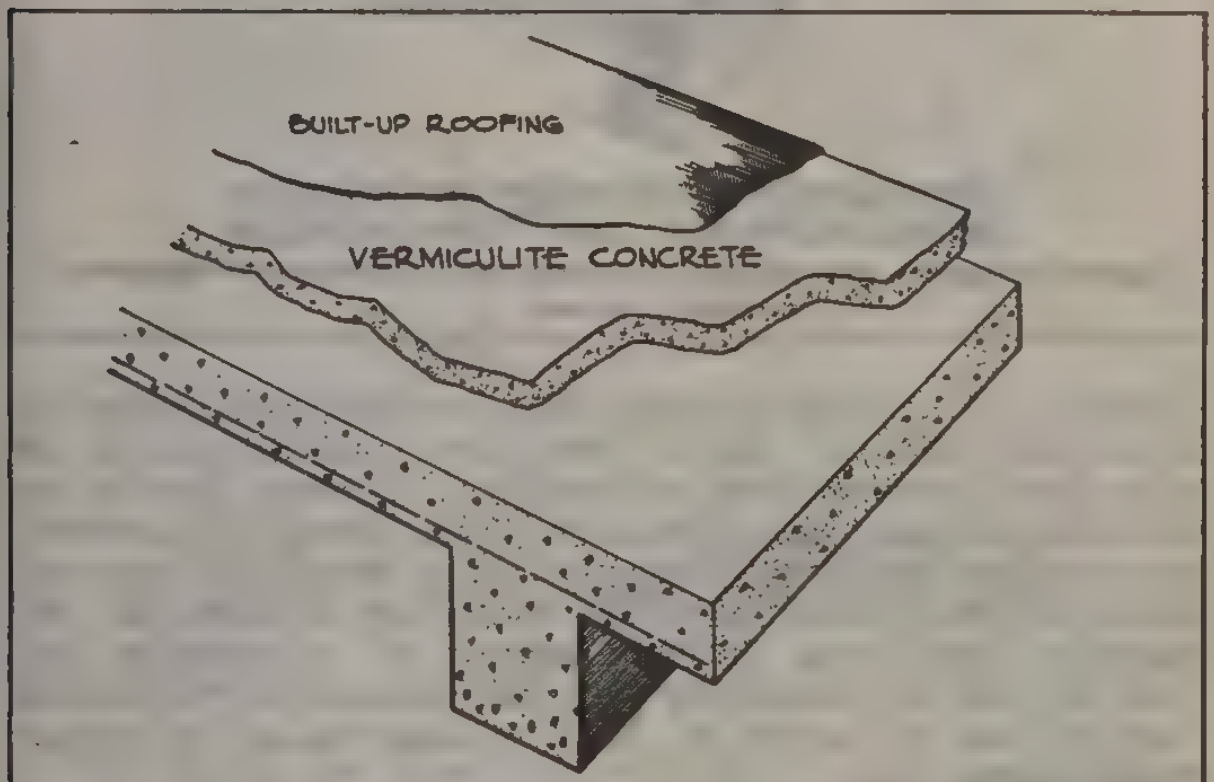
A comparison of concrete aggregates is as follows:

Type of Aggregate	Aggregate Weight per cubic foot Pounds	Weight per Cu. Ft. of Concrete Using Aggregate, Pounds
Gravel	120	150
Sand	90-100	150
Crushed stone	100	145
	Aggregate Wt. per Cu. Ft. Lbs.	Concrete Wt. per Cu. Ft. Lbs.
Crushed Bank Slag	80	100-130
Haydite	40- 60	100-120
Foamed slag	40- 60	90-100
Cinders	40- 50 (plus sand)	110-115
Pumice	30- 60	60- 90
Diatomite	28- 40	55- 70
Perlite	6- 16	20- 50
Vermiculite	6- 10	20- 40
Waylite	40- 60	90-100
Expanded Shale	44- 58	92- 98

Vermiculite Insulating Concrete Aggregate.—Vermiculite concrete aggregate is a type of mica which is mined, crushed and

screened to size. When subjected to a temperature of about 2,000°F., it expands into a laminated granule containing millions of tiny dead air cells. This produces a lightweight aggregate weighing 6 to 10 lbs. per cu. ft., as compared to sand or crushed rock aggregate weighing about 100 lbs. per cu. ft. vermiculite has high insulating value, is fireproof and will not rot or decay.

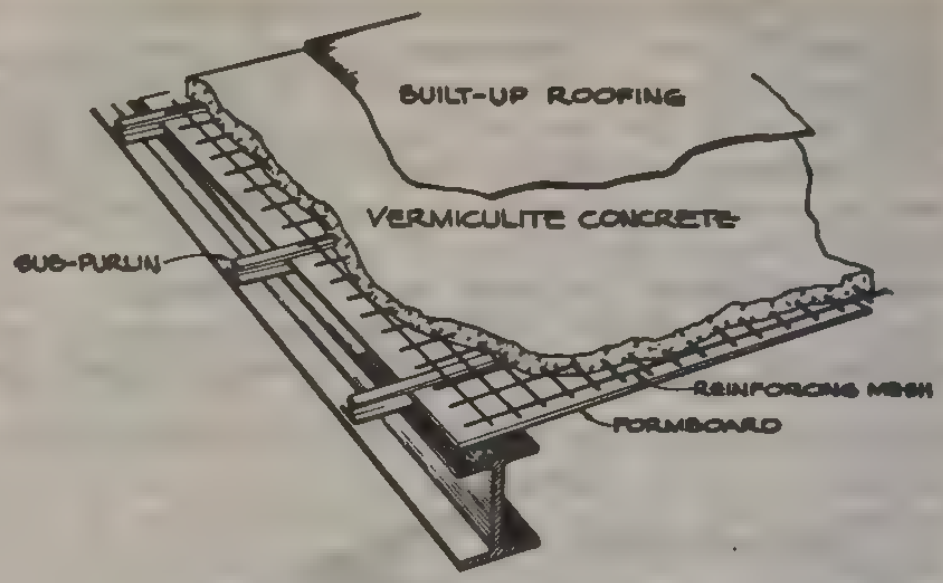
Vermiculite insulating concrete is a lightweight building material made like ordinary portland cement concrete, except vermiculite concrete aggregate is used instead of sand, gravel



VERMICULITE CONCRETE ROOF INSULATION POURED OVER STRUCTURAL CONCRETE ROOF DECKS

or crushed stone. Depending on the amount of vermiculite aggregate used, it is possible to make concrete weighing from 20 to 40 lbs. per cu. ft. Ordinary concrete weighs 145 to 150 lbs. per cu. ft.

Vermiculite concrete is used for poured concrete roof decks over a variety of forming materials; for roof insulation over such surfaces as concrete, steel, wood, etc.; for cants, saddles and drainage slopes; and for poured concrete floor slabs. The newest use for vermiculite concrete is in spandrel wall construction, where it forms the backup and is combined with an exterior facing such as aluminum, steel or porcelain enamel.



VERMICULITE CONCRETE ROOF DECK
POURED-IN-PLACE OVER FORMBOARDS

CEMENT-ASBESTOS, GYPSUM, INSULATING FIBERBOARD; ACOUSTICAL FIBERBOARD
FIBROUS GLASS

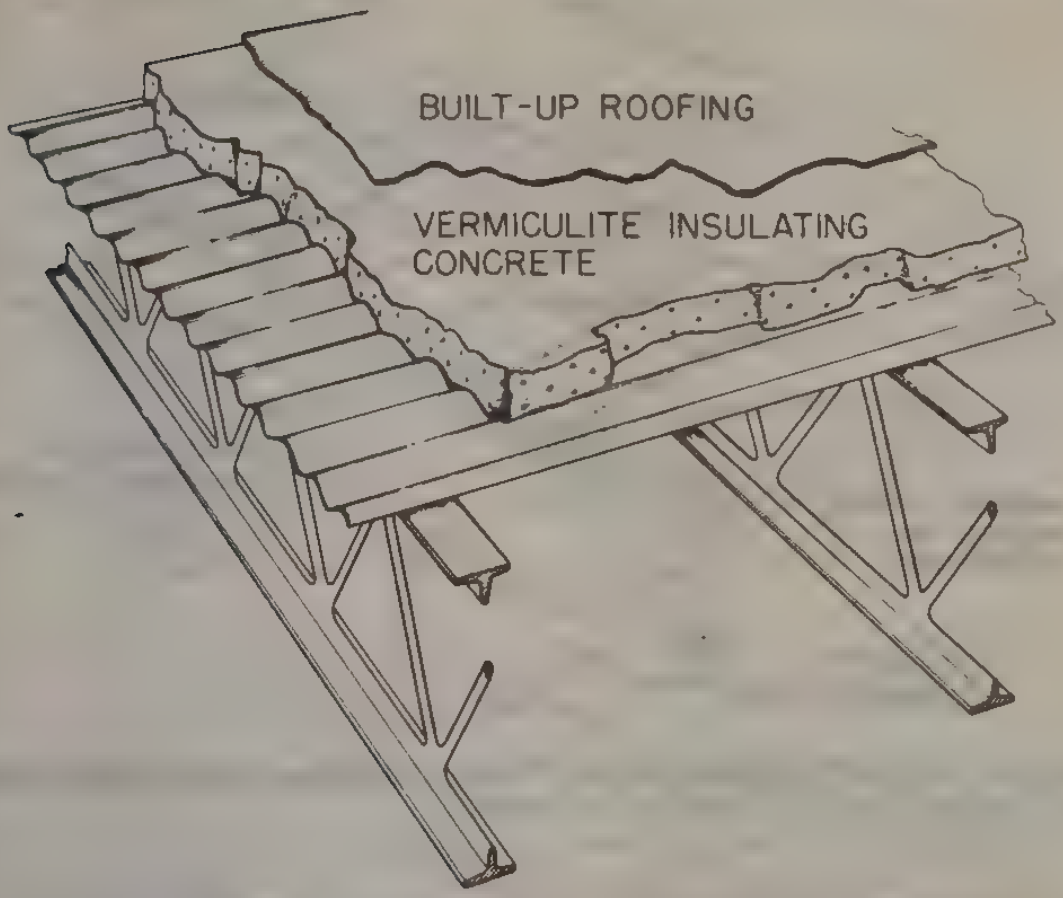
Because of its high insulation value, vermiculite concrete is an excellent base for radiant heat floor installations and for grade level floors without radiant heat in homes, farm structures and all types of commercial buildings. Vermiculite concrete has excellent insulating properties. At a density of approximately 25 lbs. per cu. ft., 1" of vermiculite concrete has an insulating value equal to approximately 16" of ordinary concrete. The density, insulating value and strength of vermiculite concrete can be varied to meet a wide range of design requirements.

Vermiculite concrete is incombustible and has earned the highest fire ratings attainable. It carries a 5-hour fire rating for spandrel wall construction and a 1½-hour rating on a steel deck covered with 1½" of vermiculite concrete and completely unprotected on the underside.

Mixing.—Vermiculite concrete should be mixed in a mechanical mixer. The required amount of water and cement shall be placed in the mixer, and then the aggregate. Mixing shall be limited to the minimum time required to obtain a thorough mix and proper fluidity. (Maximum time recommended—5 minutes)

Note—When transit-mixed vermiculite concrete is used, the operation shall be as follows:

(a) Introduce water and cement into mixer. (Fill auxiliary water tank before leaving plant)



VERMICULITE INSULATING CONCRETE OVER VENTED METAL ROOF DECKS

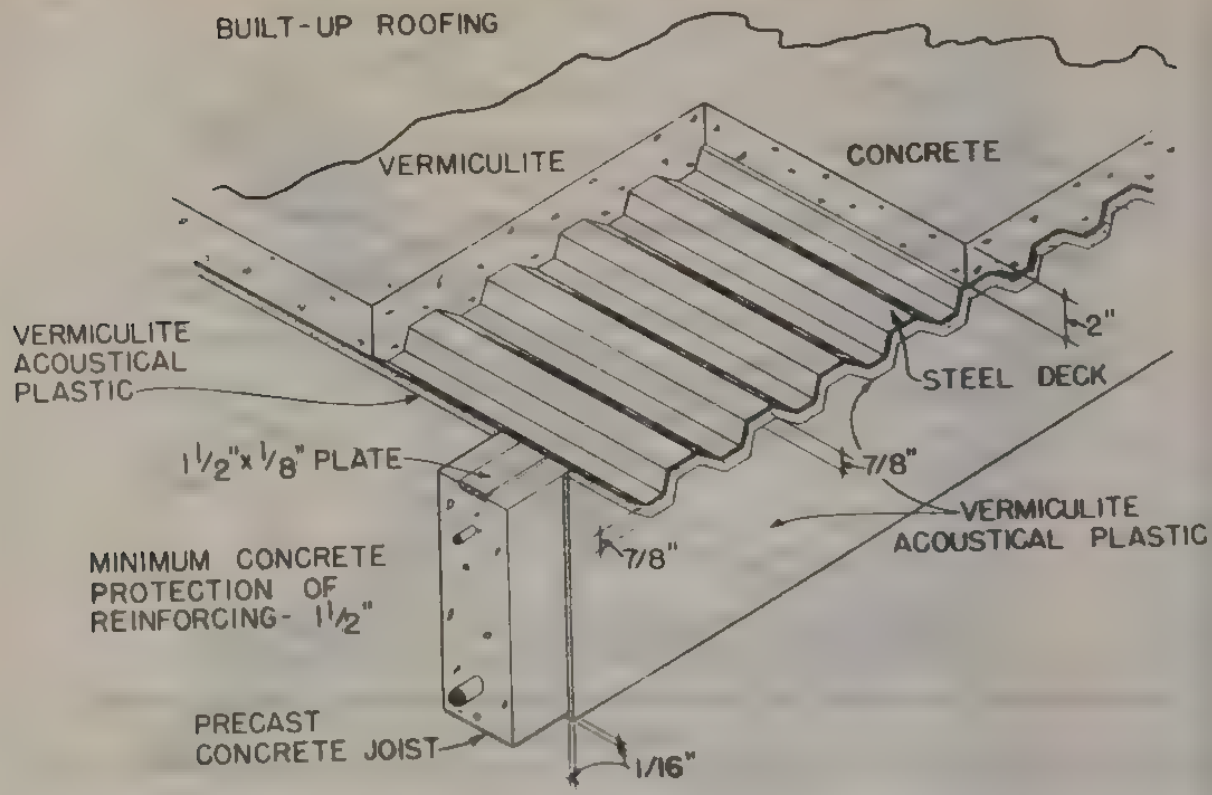
(b) Rotate the mixer slowly until all aggregate has been added.

(c) Continue to rotate mixer for approximately one minute after aggregate is in the mixer.

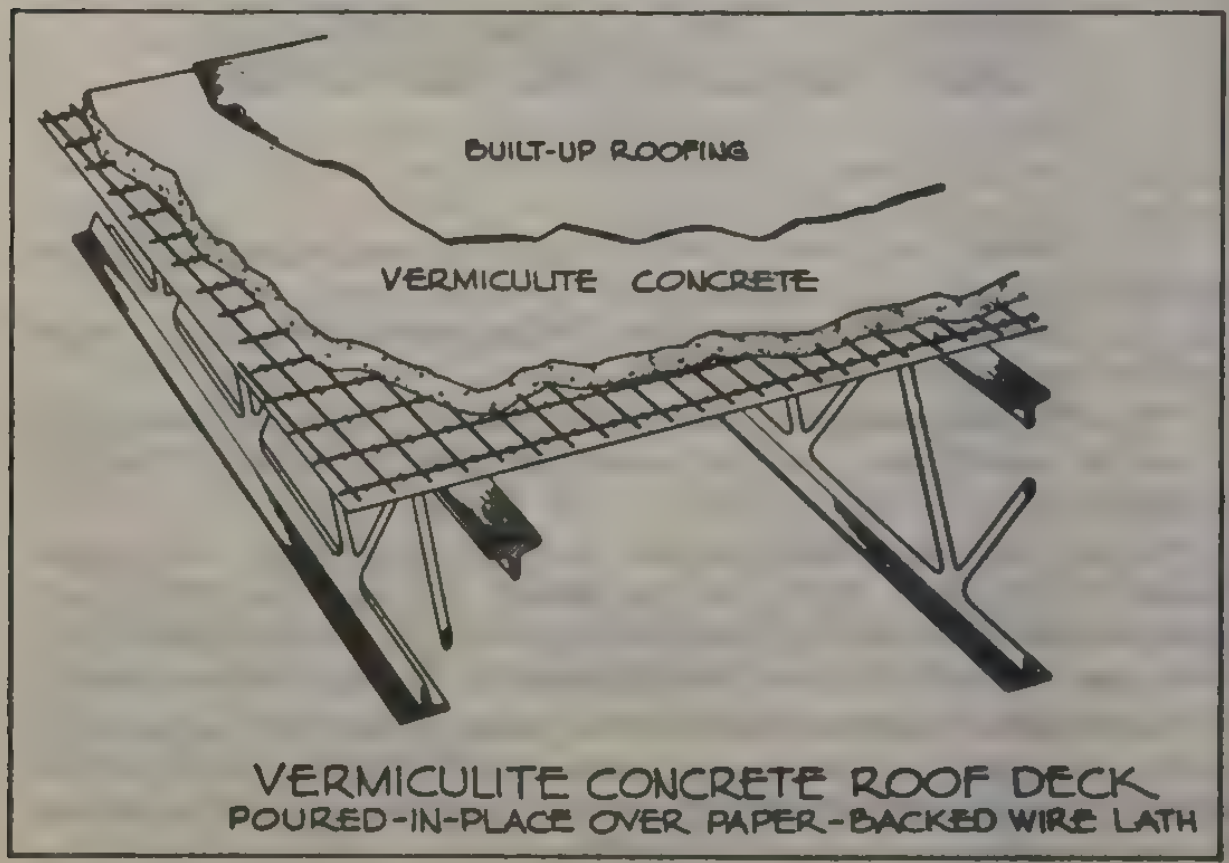
(d) Do not rotate drum on way to job site. Mix concrete at job site at fastest speed until it is uniform and flows freely from the mixer.

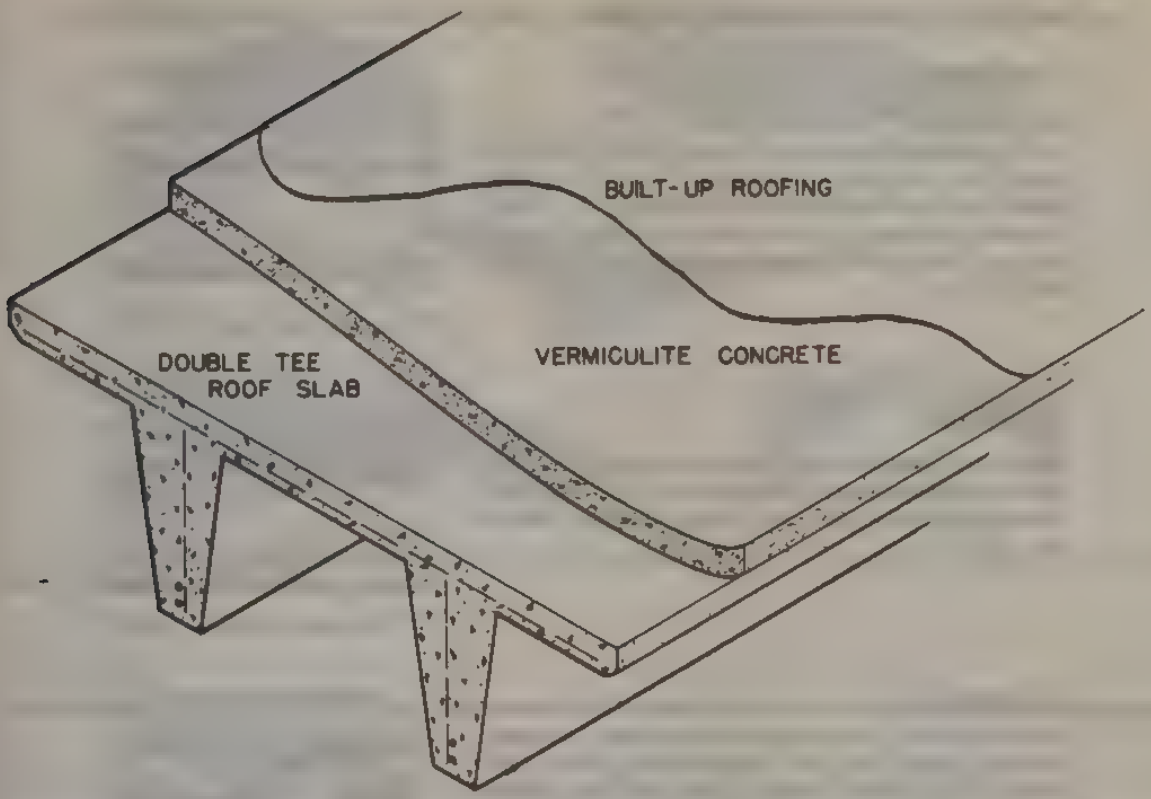
Placing.—Vermiculite concrete shall be transported and placed immediately after mixing is completed, and the period between completion of the mixing and placing shall be of such short duration that the mixture does not appreciably change in consistency.

Vermiculite concrete shall not be placed when the temperature is less than 40°F. If the temperature expected after placing of the concrete is near or below 40°F., the mixing water shall be heated in the temperature range 75°–100°F.



Vermiculite Concrete Insulation Over Vented Galvanized Steel Roof Decks, Precast Concrete Joists. (Two-hour fire rated.)





Vermiculite Concrete Insulation Over Precast Prestressed Concrete Double Tee Roof Slabs.

Vermiculite concrete may be placed by the use of standard concrete equipment such as bucket hoists, buggies or by specially designed pumping equipment.

Machine Placement.—The use of high volume pumps to install cast-in-place vermiculite insulating concrete is an important development. Pumping or spraying the concrete is especially suited to roof decks with curved, sloped or irregular surfaces, and is just as efficient on flat roof decks.

A pump is fast and simple. It can be set up or taken down in about 30 minutes. The long hose lengths that are possible enable the crew to get over obstructions on the job easily.

Less labor is required with machine placement to turn out the same amount of work. As much as 25,000 sq. ft. of vermiculite concrete 2½" thick (the equivalent of 175 cu. yds.) have been placed in a day by a crew of five men and a superintendent.

The Vermiculite Institute annually approves a national roster of roof deck applicators appointed by institute members to assure the highest quality of finished work.

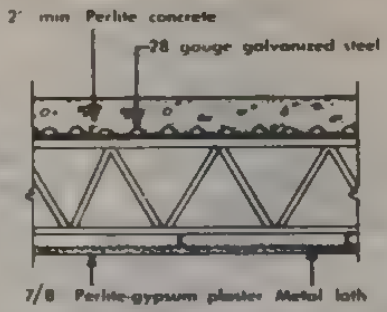
Vermiculite concrete is covered by the United States of America Standards Institute Specification A122.1-1965.

Vermiculite Insulating Concrete Floors-on-Grade.—A 1:4 mix of vermiculite concrete is recommended as an insulating base under a sand-gravel concrete topping for floors on grade. It is

— ROOF CONSTRUCTIONS

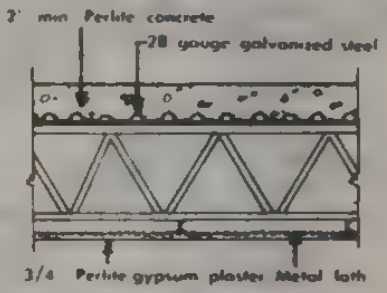
3 HOURS:

Roof deck of 2" minimum thickness perlite concrete on 28 gauge galvanized steel form units supported by steel joists 4' on center. Ceiling of ⅞" perlite-gypsum plaster on expanded metal lath attached to ¾" furring channels wire-tied to lower chord of joists. (For details see Underwriters' Laboratories Class C-3, Design No. RC1-3.)



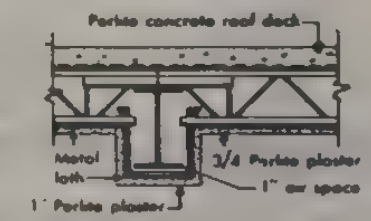
2 HOURS:

Same as 3 hour rated system above except that the perlite-gypsum plaster ceiling shall be ¾" thick. (For details see Underwriters' Laboratories Class D-2, Design No. RC11-2.)



3 HOURS:

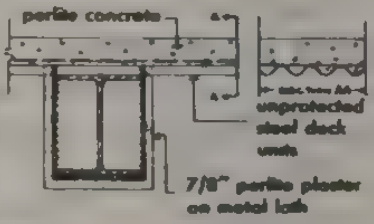
Roof deck of 2½" thickness perlite concrete on paper-backed welded wire mesh supported by steel joists. Ceiling of ¾" perlite-gypsum plaster on high ribbed metal lath attached to lower chord of joists. (For details see Underwriters' Laboratories Class C-3, Design No. RC2-3.)



1 HOUR:

UNPROTECTED STEEL ROOF DECK

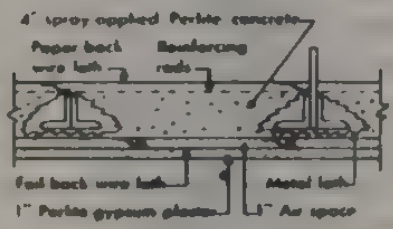
Corrugated galvanized steel deck topped with 2⅝" average thickness of perlite concrete reinforced with 48-1214 wire mesh. No ceiling protection. Beams protected with ⅞" perlite-gypsum plaster on metal lath. (For details see Underwriters' Laboratories Class E-1, Design RC2-1.)



— CURTAIN WALL CONSTRUCTIONS

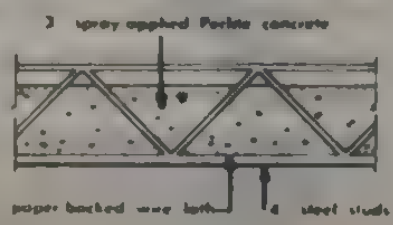
4 HOURS:

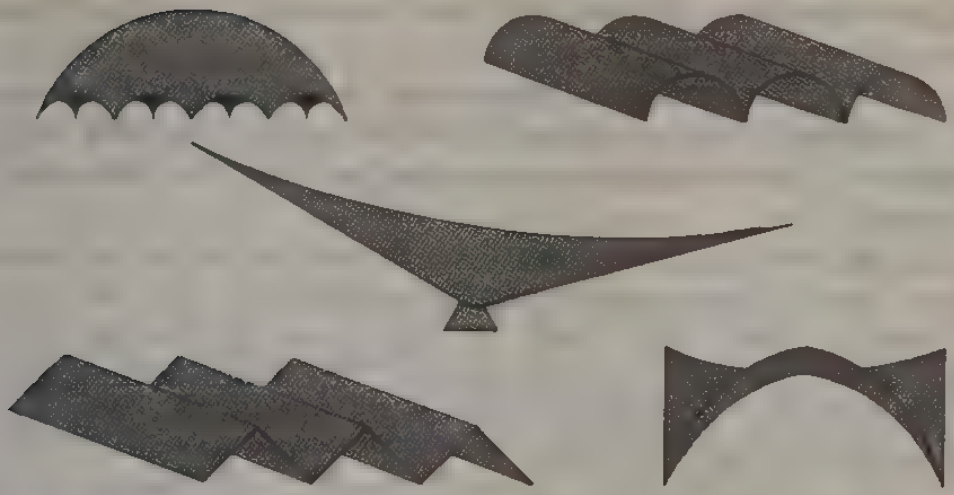
6" non-bearing wall (not including weatherproof facade). Exterior: 4" perlite-portland cement mix sprayed on paper-backed wire mesh. Interior: 1" furred perlite-gypsum plaster on paper-foil backed wire mesh. (For details see Underwriters' Laboratories Class B-4, Design No. 3.)



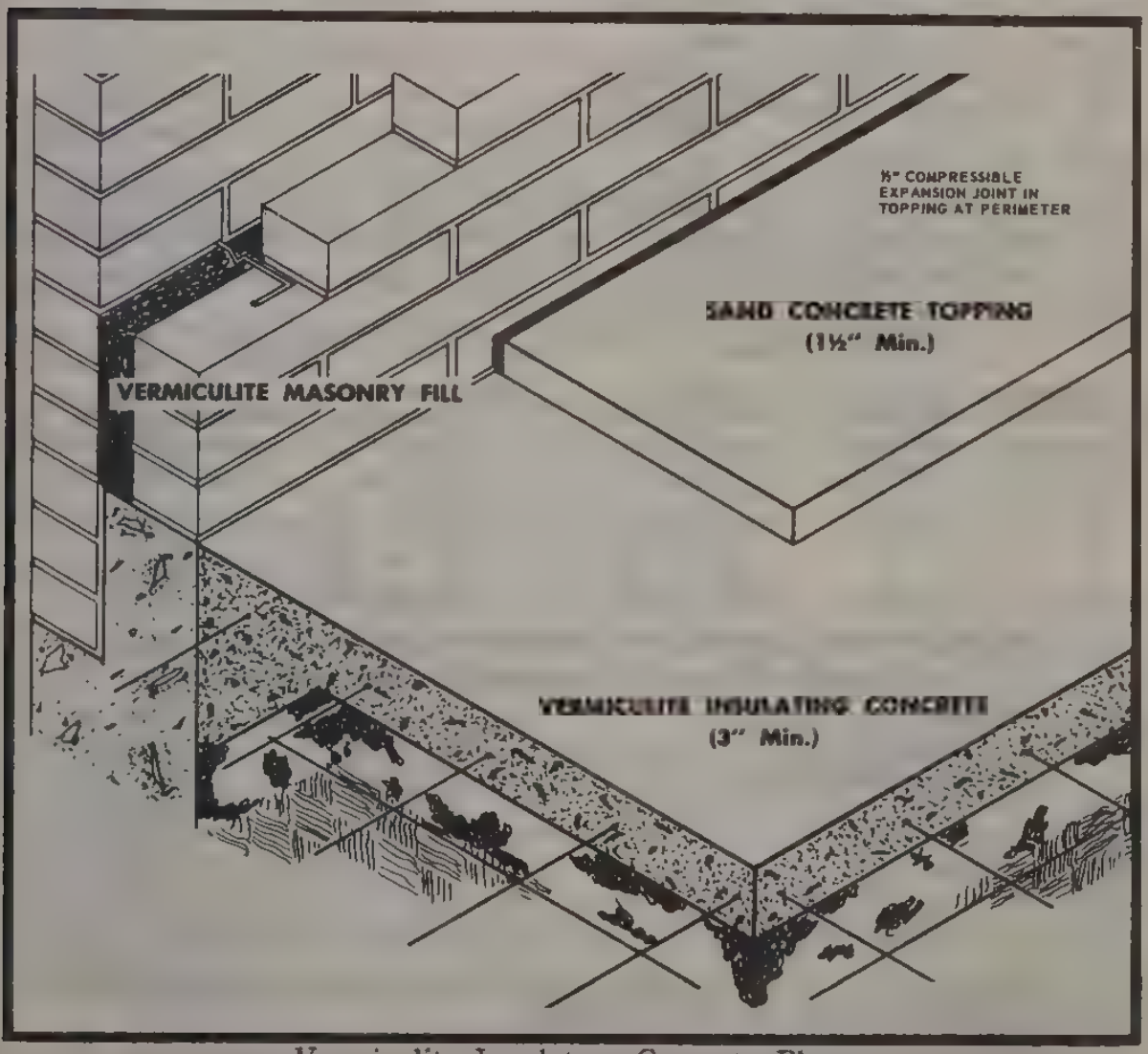
2 HOURS:

Non load-bearing wall consisting of 3" thickness perlite concrete spray-applied to paper-backed wire lath attached to 4" steel studs 16" on center. (For details see Underwriters' Laboratories Class D-2, Design No. 18.)





Various Types of Roof Construction on Which Vermiculite Insulating Concrete May Be Used.


½" COMPRESSIBLE EXPANSION JOINT IN TOPPING AT PERIMETER
SAND CONCRETE TOPPING (1½" Min.)
VERMICULITE MASONRY FILL
VERMICULITE INSULATING CONCRETE (3" Min.)

Vermiculite Insulating Concrete Floor

particularly effective in reducing heat loss where radiant heating coils or ducts are carried in the floor.

Minimum thickness of the slab should be 3". A reinforcing mesh of 6"x6"-10/10 ga. welded wire fabric, or equal, should be placed in the center of the vermiculite concrete, lapping the sides and ends one full mesh.

The sand-gravel topping should be designed to carry the maximum floor load. Minimum thickness should be 1½" except when radiant heating coils are used. In that case minimum thickness over the top of the coils should be 1". The radiant heating coils should be supported on chairs to assure a minimum of ½" of sand-gravel concrete below the coils.

Proportion Table for Vermiculite Concrete

Description of Work	Vermiculite Aggregate Cu. Ft.	Portland Cement Cu. Ft.
Poured concrete roofs	4	1
Poured concrete roof insulation	6 or 8	1
Poured concrete floor slabs		
On grade insulating slab under 1½" ordinary cement topping	4	1
Panel or spandrel walls	4	1

Vermiculite concrete aggregate comes in bags containing 4 cu. ft. and costs approximately $1.50 per bag. Always obtain local prices before submitting bids, as prices vary according to distance from distribution points, freight, etc.

Mixing Table For Vermiculite Concrete

Mixed by Volume Vermiculite Aggregate Cu. Ft.	Portland Cement Sacks	Approx. Density in Lbs per Cu. Ft.	Compressive Strength in Lbs. per Sq. In.	Thermal Conductivity (K) in btu/sq./ft./inch/hour/degree F
8	1	20 to 25	100 to 125	0.60
6	1	25 to 30	125 to 225	0.76
4	1	35 to 40	350 to 500	0.97

Approximate Quantities Required for One Cu. Yd. of Ready-Mixed Vermiculite Concrete*

Mix	Bags (4 Cu. Ft.) Vermiculite Concrete Aggregate	Sacks (1 Cu. Ft.) Portland Cement	Water Gals.
8-1	7.5	3.75	85 to 95
6-1	7.5	5.0	85 to 95
4-1	7.5	7.5	85 to 95

Do not rotate drum on way to job site. Mix concrete at job at fastest speed until it is uniform and flows freely from the mixer, adding additional water as required.

*These figures are recommended for estimating purposes. They

are based on 10 percent loss for mixing and placing. When proper mixing procedures are followed, 100 percent yield, based on aggregate volume, is attainable.

Labor Placing Vermiculite Concrete.—The labor cost of handling and placing vermiculite concrete will run about the same as other kinds of lightweight concrete used for the same purpose and using the same method of mixing and placing.

Perlite Concrete Aggregate

Perlite is a siliceous volcanic rock mined in western United States. When crushed and quickly heated to above 1500° F., it expands to form lightweight, non-combustible, glass-like particles of cellular structure. This material, white or light gray in color, weighs 7½ to 15 lbs. per cu. ft.

Perlite aggregate consists of expanded perlite sized for use in lightweight insulating concrete in place of sand or gravel. It is usually packed in 3 or 4 cu. ft. paper bags for easy handling.

The many, tiny glass sealed cells in each particle of expanded perlite make it highly insulating as well as comparatively non-absorptive. Thus perlite mixes with about 30 percent less water than comparable lightweight aggregates.

Perlite concrete, in combination with Portland cement forms a very lightweight concrete. Where ordinary concrete weighs 150 lbs. per cu. ft. the dry weight of perlite concrete can be designed from 20 lbs. to 40 lbs. per cu. ft. The extremely light weight and ease of handling make perlite concrete adaptable to practically any shape.

Perlite concrete has received up to 4-hour ratings in Underwriters' Laboratories fire tests. Its light weight makes it suitable for fireproof roof and floor fills, for thin concrete curtain walls (blocks, slabs or monolithic) and for many precast panel and block constructions.

For lightweight structural roof construction where perlite concrete is placed over galvanized steel forms, paper backed wire mesh, formboards, structural concrete, or other suitable form materials, use a 25 to 29 lb. per cu. ft. density perlite concrete. This offers an ideal balance of low dead weight, adequate compressive and indentation strengths, and good insulating value. For uses where higher strengths-compressive and indentation are more important than insulating value, i.e., floor fills and certain lightweight structural roof designs, use a 34 to 40 lb. per cu. ft. density perlite concrete.

Perlite concrete should be mixed in a paddle type plaster or a drum type concrete mixer. The required amount of water, air entraining admixture and Portland cement should be placed in

the mixer and mixed until a slurry is formed. The proper amount of perlite concrete aggregate should then be added to the slurry and all materials mixed until design wet density is reached. Perlite concrete may also be transit mixed.

Perlite concrete should be carefully deposited and screeded in a continuous operation until a panel or section is completed. Steel troweling should be avoided. Rodding, tamping and vibrating should not be used unless so specified by the architect.

It is recommended that a 1" air space or expansion joint be provided through the thickness of the perlite concrete at the juncture of all roof projections, such as skylights, penthouses, and parapet walls and perlite concrete. Expansion joints are recommended in accordance with good concrete and steel construction practice and are based upon the provision that suitable consideration has been given to the use of adequate through-building expansion joints. Other types of insulating concrete may not require expansion joints because of high initial shrinkage.

Perlite concrete, during the curing period, should be protected for at least the first three days in accordance with good job practice to keep it from drying out too rapidly or freezing. Freshly poured concrete should also be given adequate protection from heavy rain. Allow no traffic until concrete can sustain a man's weight without indentation.

Perlite concrete should not be placed in temperatures under 40° F. nor on frosted surfaces. In near-freezing weather the mixing water should be heated to between 75° and 100° F.

Perlite concrete is also used as a base for radiant heating coils or as floor slabs in basementless homes. For grade level floors a moisture resistant barrier should be used and a suitable wearing surface applied over the perlite insulating concrete.

Immense savings in dead weight are possible by using perlite concrete as a floor fill over cellular steel or pan-type floors in multiple story buildings. The surface may be covered with concrete topping and other surfacing materials after the perlite concrete has cured several days. Another floor fill material, using perlite blended with other aggregates, is perlite/sand or perlite/expanded shale concrete. These concretes have higher compressive strengths and require only resilient flooring or carpeting as a wearing surface. Following are the results of tests conducted at nationally recognized laboratories. Due to the varying characteristics of naturally occurring aggregates in different geographical areas, trial mixes of aggregate blends are recommended for determination of mix proportions.

Table of Mix Proportions

Density Wet	Density Dry	Compression 28 day, psi	Cement (Sacks)	Perlite (cf)	Heavy Aggregate (cf)	AEA† (oz)	Water U.S. Gal/Sack	Ct. Factor cu. yd.
82	72	1000	1	3	2*	6	8.5	5.82
66	54	1200	1	3	2**	4	8.5	6.12

*Sand. **Rotary Kiln Expanded Shale. †Air Entraining Agent.

Perlite concrete can be nailed, sawed and worked with ordinary carpenter tools.

Mix Proportions By Volume for Lightweight Perlite Insulating Concrete

Cement (Sacks)	Perlite Cu. Ft.	Water-Gals. per Sack Cement	Air-Entraining Agent—Pints	Density Lbs. per Cu. Ft. Oven Dry	Comp. Str. psi-28 Days
1	4	9	1	36	400
1	5	11	1¼	30½	250
1	6	12	1½	27	170
1	7	14	1¾	24	120
1	8	16	2	22	95

Material Required for One Cu. Yd. of Placed Perlite Concrete

Proportions Cement	Perlite	Cement Sacks	Perlite Cu. Ft.	Water Gallons	Air-Entraining Agent—Pints
1	4	6.75	27	61	6¾
1	5	5.40	27	59½	6¾
1	6	4.50	27	54	6¾
1	7	3.85	27	54	6¾
1	8	3.38	27	54	6¾

Cost of One Cu. Yd. of 1:4 Perlite Concrete Used for Floor Fill or Short Span Lightweight Floors, 36 Lb. Density

	Hours	Rate	Total	Rate	Total
6.75 sacks portland cement		$.....	$.....	$1.80	$12.15
27 cu. ft. Perlite.....		.....	.....	.40	10.80
6.75 pints air entrain. agt..		.....	.....	.20	1.35
Labor	3	.....	.....	5.00	15.00
Cost per cu. yd.....	3		$.....		$39.30
Cost per sq. ft. 2" thick....					.242
Cost per sq. ft. 3" thick....					.364

Add for mixer engineer and hoisting engineer, if required.
Add for setting screeds and all finishing work.

Cost of One Cu. Yd. of 1:6 Perlite Concrete Used for Floor Fill or Short Span Lightweight Floors, 27-Lb. Density

	Hours	Rate	Total	Rate	Total
4.50 sacks portland cement		$.....	$.....	$1.80	$ 8.10
27 cu. ft. Perlite.....		.....	.....	.40	10.80
6.75 pints air entrain. agt...		.....	.....	.20	1.35
Labor	3	.....	.....	5.00	15.00
Cost per cu. yd.....	3		$.....		$35.25
Cost per sq. ft. 2" thick....			.....		.218
Cost per sq. ft. 3" thick....			.....		.326

Add for mixer engineer and hoisting engineer, if required.

Add for setting screeds and all finishing work.

Cost of One Cu. Yd. of 1:6 Perlite Concrete Used for Roof Fill or Short Span Structural Roof Decks, 27-Lb. Density, on Pitch or Gable Roofs

	Hours	Rate	Total	Rate	Total
4.50 sacks portland cement		$.....	$.....	$1.80	$ 8.10
27 cu. ft. Perlite.....		.....	.....	.40	10.80
6.75 pints air entrain. agt...		.....	.....	.20	1.35
Labor	4	.....	.....	5.00	20.00
Cost per cu. yd.....	4		$.....		$40.25
Cost per sq. ft. 2" thick....			.....		.248
Cost per sq. ft. 3" thick....			.....		.373

Add for mixer engineer and hoisting engineer, if required.

Add for setting screeds and all finishing work.

Cost of One Cu. Yd. of 1:7 Perlite Concrete Used for Roof Fill or Short Span Structural Roof Decks, 24-Lb. Density, on Pitch or Gable Roofs

	Hours	Rate	Total	Rate	Total
3.85 sacks portland cement		$.....	$.....	$1.80	$ 6.93
27 cu. ft. Perlite.....		.....	.....	.40	10.80
6.75 pints air entrain. agt...		.....	.....	.20	1.35
Labor	4	.....	.....	5.00	20.00
Cost per cu. yd.	4		$.....		$39.08
Cost per sq. ft. 2" thick....			.....		.241
Cost per sq. ft. 3" thick....			.....		.362

Add for mixer engineer and hoisting engineer, if required.

Add for setting screeds and all finishing work.

Cost of One Cu. Yd. of 1:6 Perlite Concrete Used for Roof Fill or Short Span Structural Roof Decks, 27-Lb. Density, on Flat Surfaces

	Hours	Rate	Total	Rate	Total
4.50 sacks portland cement		$.....	$.....	$1.80	$ 8.10
27 cu. ft. Perlite.....		.....	.....	.40	10.80
6.75 pints air entrain. agt...		.....	.....	.20	1.35
Labor	2.7	.....	.....	5.00	13.50
Cost per cu. yd.....	2.7		$.....		$33.75
Cost per sq. ft. 2" thick....			.....		.208
Cost per sq. ft. 3" thick....			.....		.312

Add for mixer engineer and hoisting engineer, if required.

Add for setting screeds and all finishing work.

Cost of One Cu. Yd. of 1:7 Perlite Concrete Used for Roof Fill or Short Span Structural Roof Decks, 24-Lb. Density, on Flat Surfaces

	Hours	Rate	Total	Rate	Total
3.85 sacks portland cement		$.....	$.....	$1.80	$ 6.93
27 cu. ft. Perlite.....		.....	.....	.40	10.80
6.75 pints air entrain. agt...		.....	.....	.20	1.35
Labor	2.7	.....	.....	5.00	13.50
Cost per cu. yd.....	2.7		$.....		$32.58
Cost per sq. ft. 2" thick....			.....		.201
Cost per sq. ft. 3" thick....			.....		.302

Add for mixer engineer and hoisting engineer, if required.

Add for setting screeds and all finishing work.

Pumice Concrete

Pumice is a natural white or gray glass foam. It is not a volcanic ash. It is mined extensively in the western part of the United States.

Uniform graded pumice is used as aggregate in monolithic concrete, concrete masonry units and precast products. It replaces sand and gravel in any concrete up to strengths of 3,000 lbs. per sq. in., where thermal insulation, acoustical and light weight properties are desirable.

All pumice aggregate shall be clean, free of all foreign matter and well graded so as to meet A.S.T.M. specifications C-330.

All water used in concrete work shall be free from oil, strong acids, alkali, or organic material.

Mixing.—Concrete for columns, walls above ground, floors,

window sills and all self-supporting floor and roof slabs, canopies, and other parts of structure not coming in contact with ground shall be of a mixture of water, portland cement, and pumice aggregate, and shall develop at 28 days a strength of not less than 2,500 psi. and with a slump of not more than 2" by standard test.

Water contained in the aggregate shall be deducted from the amount of water used in the mix except that the water needed to saturate the pumice aggregate shall not be deducted. Pumice aggregate shall be thoroughly saturated either in the stockpile or in the mixer prior to the addition of cement and water for mixing.

SUGGESTED MIX DESIGN DATA FOR PYRAMID PUMICE CONCRETE

Compression lbs/sq in	Design Weight lbs/cu ft	Sand lbs (dry)	Pyramid Pumice per Cubic Yard Yield						Cement		Water				Recommended slump
			Fine		Coarse		Blend		sax/cu yd yield	lbs/cu yd yield	to saturate		to mix		
			lbs (dry)	cu ft	lbs (dry)	cu ft	lbs (dry)	cu ft			gal	lbs	gal	lbs	
150	40	0	0	0	792	36	0	0	4	376	36.1	300	Determine by sight		0
250	46	0	914	24	264	12	1180	36	3	282	34.8	290	Determine by sight		0
500	55	0	914	24	264	12	1180	36	4	376	34.8	290	Determine by sight		0
1000	60	0	914	24	264	12	1180	36	5	470	34.8	290	50	417	½"
1500	65	0	914	24	264	12	1180	36	6.5	611	34.8	290	52	433	½"
2000	70	0	914	24	264	12	1180	36	7.5	705	34.8	290	53	442	1"
2500	75	0	914	24	264	12	1180	36	8	752	34.8	290	48	400	2"

Note: Pyramid Pumice Aggregate should be saturated prior to the addition of cement. This may be done in the stock pile or in the mixer. A 1" slump in pumice concrete will give a consistency equal to a 3" slump in hard rock concrete. Pumice concrete should be mixed with as little water as possible to get the required workability. It should be the consistency of thick mud and no free water should be in evidence. Air entraining agents are recommended to cut water-cement ratio and get greater workability. A combination of fine and coarse aggregate or the blended aggregate should be used. Volume measurements are based on loose volume non-compacted pumice.

Placing.—All pumice concrete shall be thoroughly vibrated with a mechanical vibrator. Vibration shall be conducted in such a manner as to assure that the vibrator passes through the pumice mass with not more than 6 inches of space between the successive positions of the vibrator. In all cases where pumice is placed in layers the vibrator must penetrate into the underlying concrete layer after passing through the newly placed layer. Ample time shall be allowed for the settlement of the concrete before final topping or screening to finished floor level

or grade. The pumice aggregate shall be thoroughly saturated prior to mixing with the cement and water used for mixing and ample time shall be allowed for the saturation to take place.

Application.—Pumice must be handled carefully if it is to be successful. Because it will float it must be pre-saturated before use. The stock pile should be sprayed for at least 48 hours or the pumice should be saturated in the mixer before use. Unless this is done, cement particles will be drawn into the cells of the pumice and excessive shrinkage may occur as a result of loss of water from the mix to the pumice particles. One half of the total water required should be added to the aggregate before the cement is introduced.

The concrete should be water cured for at least seven days after which time the outer fibers will have become strong and dense enough to protect against evaporation and resultant too rapid drying.

Gradations Available.—Pumice aggregate is graded to meet A.S.T.M. specifications for properly graded lightweight aggregrates for concrete. Designation C-330 in sizes No. 4 to 0 for fine aggregate; $\frac{3}{8}$ and $\frac{1}{2}$ to 0 for blended aggregate; $\frac{1}{2}$" to No. 4 for coarse aggregate.

Shipping Weight.—Fine material or $\frac{1}{4}$" to 0 aggregate will have an average weight of about 1,200 lbs. per cu. yd. Blended aggregate or $\frac{3}{8}$" to 0 material will weigh about 1,100 lbs. per cu. yd. The coarse aggregate or $\frac{1}{2}$" to No. 4 material will have an average shipping weight of about 800 lbs. per cu. yd. These weights may increase from 100 to 200 lbs. per cu. yd. during wet seasons.

An open top, side dump, flat bottom (Caswell) car carries approximately 63 cu. yds. of material.

An open top, solid bottom, gondola car will carry approximately 63 cu. yds. of material.

An open top, hopper bottom car will vary in capacity from 60 to 100 cu. yds.

Cost of Pumice Aggregate.—The cost of pumice aggregate varies with the locality as the freight is a big item entering into the cost.

Pumice aggregate costs approximately $3.00 per cu. yd., f.o.b. plants in the Arizona and New Mexico area. To this cost must be added charges for freight or trucking to job site.

Waylite Lightweight Aggregate.—A lightweight, cellular aggregate, refined and expanded by a process of agitating and rapidly cooling in an atmosphere of steam molten hot slag as it comes from the blast furnace at temperatures of 2500 to 3000° F. In this process the inherent gases expand and fill the ma-

terial with minute air cells or bubbles completely sealed. These minute air cells are the active insulation and lightweight principle in all Waylite aggregates.

Waylite aggregate crushed and screened is available in three commercial sizes and average dry loose weights per cubic foot.

Aggregate	Grading	Average Weight
Coarse	$\frac{7}{16}$" to $\frac{3}{8}$"	40 lbs.
Acoustical	$\frac{3}{8}$" to $\frac{3}{32}$"	45 lbs.
Fine	$\frac{1}{8}$" to dust	60 lbs.

Waylite concrete requires a higher proportion of fine aggregate in relation to coarse than ordinary concrete. This is due to the lower top sizes of the coarse aggregate ($\frac{7}{16}$") and the additional angularity or harshness of the crushed fine and coarse aggregates.

The mixing of Waylite concrete requires a somewhat different manipulation procedure than for heavy aggregates. To obtain maximum workability with minimum weight, the aggregate and water should be mixed for one-half minute before the addition of the cement, and then mixed for at least an additional two minutes. A mix which appears harsh at first will improve in plasticity with continued mixing without additional water.

WAYLITE CONCRETE MIX DATA

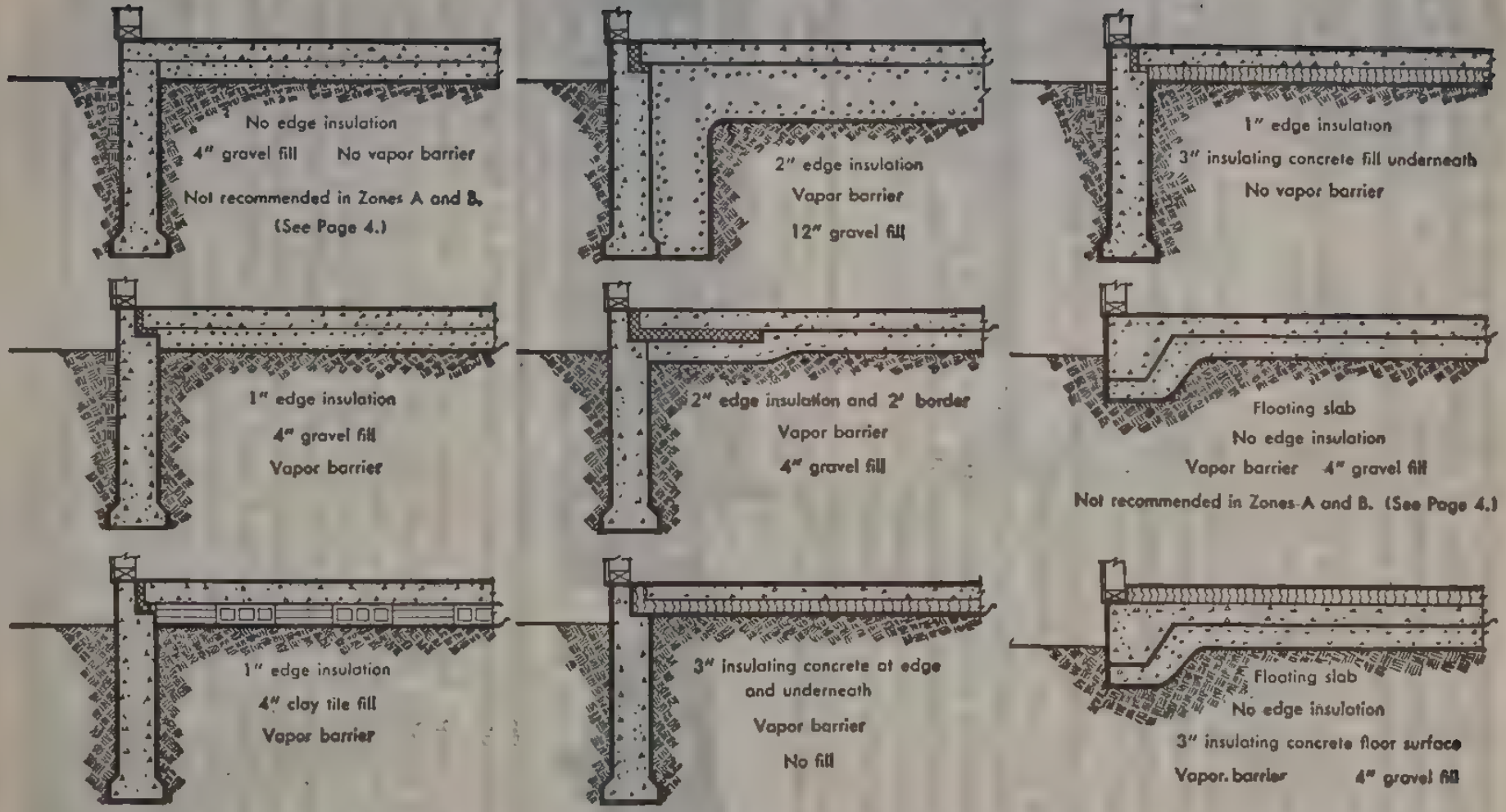
Mix Loose Volume	Gals. Water per Sack	Quantities Required per Cu. Yd., Loose Dry Volume: Cement Sacks	Fine Waylite Cu. Yds.	Coarse Waylite Cu. Yds.	Sand* Cu. Yds.
1-2¼-2½-¾*	9.4	6.4	0.53	0.60	0.17
1-2 -2¼-¾*	8.2	7.2	.53	.60	.20
1-1¾-2 -½*	7.3	8.1	.54	.60	.15
1-1½-2 -½*	6.5	8.8	.49	.65	.17
1-1½-1¾-½*	5.9	9.6	.53	.62	.18

The addition of approved concrete air entraining agents materially improve the workability of Waylite concrete mixes.

*Sand shall be a fine siliceous bank, lake, or mason sand.

CONCRETE FLOORS FOR BASEMENTLESS HOUSES

The convenience and economy of the one floor basementless house have resulted in the increased use of concrete floors laid on the ground. This type of floor has been built without adequate test data or established construction standards relating to conditions involving comfort—dampness and floor temperature. Many such floors have proved to be cold, especially at the outer edge. Some have also been damp—damp enough to damage floor coverings and wall construction.



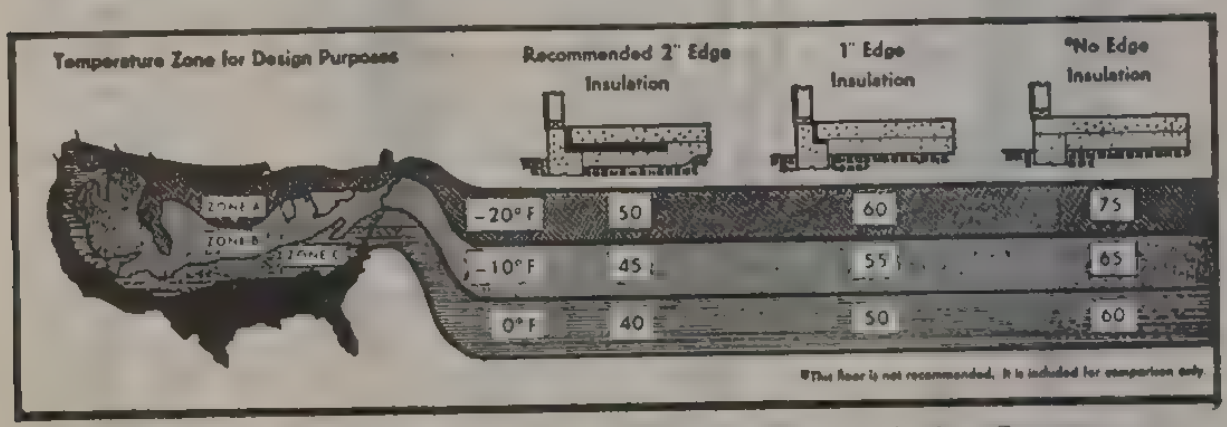
Methods of Constructing Concrete Floors for Basementless Houses.

To determine the most satisfactory floor from the standpoint of comfort, the University of Illinois* has studied the construction of concrete floor slabs which are laid on the ground and which are designed for use in climates where central heating is desirable.

Nine different types of concrete floors were tested in an effort to determine the proper design for floors for basementless houses with respect to:

1. Heat losses of the different types of floors.
2. Temperatures at various points throughout the floors. This information was sought for proper placement of floor insulation.
3. The amount of moisture passing from the ground to the top of the concrete slab.

The floors selected for tests represented standard construction practices and, at the same time, permitted the use of varying amounts and types of insulation along the edges. The floor slabs were tested simultaneously under similar conditions in a specially constructed laboratory.



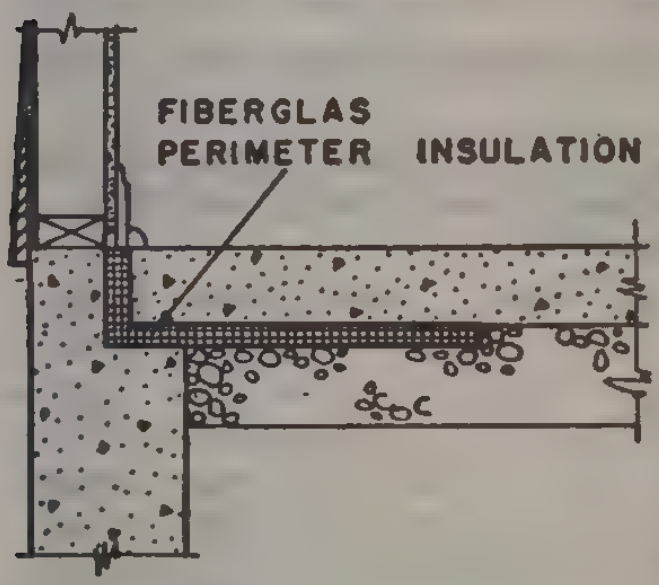
Insulation Requirements for Different Parts of the Country.

When panel heating systems are used with concrete floors, the heat loss to the ground and at the edge is increased due to the higher temperatures maintained in the floors. To prevent excessive heat losses in such floors, a minimum of 2 inches of rigid waterproof insulation should be provided at the edge. In addition, the use of insulation under the entire heated floor area is recommended. Gravel and rock fills are desirable for drainage controls, but they have no insulating value.

Estimating the Cost of Concrete Floors for Basementless Houses.—When estimating the cost of concrete floors for this type of construction, the floors are estimated the same as any

*Reprinted by permission Small Homes Council from its circular F4.3, "Concrete Floors for Basementless Houses."

other type of concrete floors covering the same specification. For instance, if insulation is specified along the outside walls and under the floors, this should be estimated as a separate item, and then the floor construction consisting of a vapor barrier, slag or gravel fill, insulating concrete, plus the cost of the structural concrete floor.



It is difficult to give an example of floor cost of this type because it is practically impossible to know just how much insulation will be required per 100 sq. ft. of floor.

Fiberglas Perimeter Insulation.—The use of concrete floor slabs for basementless homes requires an insulating material around the perimeter of the slab (at the exterior walls) which will not be compressed by imposed loads or soil backfill and which will not be affected by soil acids, moisture, insects or vermin.

Fiberglas Perimeter Insulation is used successfully for this purpose, Type AE-6, comes in panels 12"x36"x1" thick, has a density of 6 lbs. per cu. ft. and is asphalt enclosed.

Approximate Price per sq. ft. $0.17

Cost of 100 Sq. Ft. of Concrete Floor Placed on the Ground, Such as Used in Basementless Houses, Using Gravel Concrete

Floor consists of 4" gravel fill, vapor barrier and 4" concrete slab.

	Hours	Rate	Total	Rate	Total
37 cu. ft. gravel fill.....		$.....	$.....	$0.15	$ 5.55
Labor spreading, grading.	1.80	.....	....	5.00	9.00
Vapor Barrier Paper					
120 sq. ft. paper		.....	....	2.00	2.40
Coal tar pitch, 15 lbs.....		.....	....	.03	.45
Concrete floor 1:2¼:3½					
7.1 sacks portland cement.		.....	....	1.80	12.78
0.59 cu. yds. sand.....		.....	.....	4.00	2.36
0.92 cu. yds. gravel.....		.....	....	4.00	3.68
Labor	3.10	.....	....	5.00	15.50
Carried Forward	4.90	.....	....		$51.72

	Hours	Rate	Total	Rate	Total
Brought Forward	4.90	$.....	$....	$....	$51.72
Set Screeds and Trowel Floor Finish					
Cement mason	1.70	.....	....	6.50	11.05
Helper	1.45	.....	....	5.00	7.25
Cost per 100 sq. ft.	8.05		$.....		$70.02
Cost per sq. ft.			.....		.70

Add for edge insulation and insulation under slab around outside edge of building.

Cost of 100 Sq. Ft. of Concrete Floor Placed on the Ground, Such as Used in Basementless Houses, Using Insulating Concrete

	Hours	Rate	Total	Rate	Total
37 cu. ft. gravel fill		$.....	$.....	$0.15	$ 5.55
Labor spreading and grading	1.80	.....	.....	5.00	9.00
Vapor Barrier Paper					
120 sq. ft. paper		.....	.....	2.00	2.40
Coal tar pitch, 15 lbs.		.....	.....	.03	.45
3"Insulating Concrete Floor 1:6					
27.6 cu. ft. Vermiculite		.....	.....	.40	11.04
4.6 sacks portland cement.		.....	.....	1.80	8.28
Labor.	2.30	.....	.....	5.00	11.50
Set Screeds and Strike Off					
Cement mason	0.80	.....	.....	6.50	5.20
Helper	0.40	.....	.....	5.00	2.00
3" Structural concrete floor 1:2¼:3½					
5.4 sacks portland cement.		.....	.....	1.80	9.72
0.45 cu. yds. sand		.....	.....	4.00	1.80
0.70 cu. yds gravel		.....	.....	4.00	2.80
Labor	2.30	.....	.....	5.00	11.50
Set Screeds and Trowel Floor Finish					
Cement mason	1.70	.....	.....	6.50	11.05
Helper	1.45	.....	.....	5.00	7.25
Cost per 100 sq. ft.	10.75		$.....		$99.54
Cost per sq. ft.			.....		.995

Add for edge insulation and insulation under slab around outside edge of building.

Cleaning Concrete Floors Using a Sanding Machine.—To clean droppings of paint, mortar, joint finishing cement, etc., from concrete floors before laying asphalt, rubber or plastic floor tile, a power sanding machine does a satisfactory job at a considerable saving in labor.

This is accomplished by using a floor maintainer equipped with a sanding disk and open grit silicon carbon grain paper, which cuts through and removes the droppings satisfactorily.

The sanding operation should be done before the final coat of paint is applied, so that any touch-up necessary on the wood baseboard could be done without making a special operation. After the floors have been sanded the same operator uses an industrial vacuum cleaner to pick up all of the sanding dust. The vacuum cleaner has a dual purpose as it is also used to clean the house before it is turned over to the owner.

A man operating a sanding machine will clean about 500 sq. ft. of floor an hour at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Machinery cost		$.....	$.....	$0.15	$0.15*
Sanding disk		.....	.....	.12	.12†
Labor	0.2	.....	.....	5.00	1.00
Cost per 100 sq. ft.	0.2		$.....		$1.27
Cost per sq. ft.			.....		.013

*The sanding machine and vacuum cleaner cost about $900.00.

†One sanding disk at $0.12 should clean about 1,000 sq. ft. of floor.

When this work is performed by hand using a putty knife or steel scraper, a man will clean and remove droppings from 150 to 175 sq. ft. an hour, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.6	$.....	$.....	$5.00	$3.00
Temporary paper covering		.....	.....	.35	.35
Cost per 100 sq. ft.	0.6		$.....		$3.35
Cost per sq. ft.			.....		.034

CONCRETE CURB, GUTTER & PAVING

This article is not intended to cover road building but only small curb and gutter jobs, and small concrete paving projects.

Large jobs of this kind require a vast amount of equipment and the costs vary widely according to the amount of cut and fill required, method of receiving materials, etc., as many contractors who specialize in this work have their own gravel crushing and screening plants, while others maintain elaborate plants at the nearest railroad siding for unloading materials from cars, loading trucks, etc.

When making up an estimate on curb and gutter work, and

concrete paving, it should include all items of overhead expense, such as superintendent, foremen, timekeepers, watchmen, etc.

The item of plant and equipment should include the cost of transporting equipment to the job and removing same at completion, and includes the following items: power shovels, bulldozers, tractor shovels, power rollers, trucks, tractors, ditching machines, self-feeding loaders, belt conveyors, concrete mixers, concrete carts or tractors, wood or metal forms for curb and gutter, templates for street grades, tar kettle and pots, tool boxes, etc. These items should be estimated on the basis of total transportation costs both ways and a rental charge for plant and equipment. The total should be divided by the number of sq. yds. of pavement in the job, as it is customary to submit bids on paving at a certain price per sq. yd. including profit.

Excavating and Grading for Pavements.—For costs on all classes of excavation and grading, refer to Chapter V.

Excavating for Curb and Gutter.—Refer to Chapter V for costs on hand and trenching machine excavating.

Excavating for Storm Sewers.—Refer to Chapter V for costs on trench excavating by hand and machine.

Rolling Streets and Roads.—After the excavating and grading has been completed, the subgrade should be rolled to provide a solid foundation to receive the concrete base. A power roller, with engineer, should roll 130 to 150 sq. yds. of subgrade an hr. at the following cost per 100 sq. yds.:

	Hours	Rate	Total	Rate	Total
Engineer	0.7	$.....	$.....	$6.75	$4.73
Power roller	0.7	.....	.....	4.30	3.01
Cost per 100 sq. yds.	0.7	.....	$		$7.74
Cost per sq. yd.					.077

When the contractor does not have his own power roller on the job, they may often be rented from the City authorities for whom the work is being done. The rental is often charged at a certain price per sq. yd. of pavement, and may run from 6 to 10 cts.

Hauling Sand, Gravel, Crushed Stone, Etc.—The cost of hauling paving materials will vary with the length of haul from pit or cars to point of delivery. Tables of hauling time are given under "Excavating."

Hauling Cement—The cost of unloading and hauling cement will vary with the method of unloading, length of haul, etc.

When hauling cement over paved streets or roads a truck should carry from 5,000 to 25,000 lbs. depending upon capacity.

Unloading Cement.—When unloading cement from cars or warehouses into trucks, a man will unload about 400 sacks per 8-hr. day, at the following labor cost per 100 sacks (25 bbls.):

	Hours	Rate	Total	Rate	Total
Labor	2.0	$.....	$.....	$5.00	$10.00
Cost per bbl.			.....		.40

Concrete Curb and Gutter

When estimating the cost of forms for concrete curb or curb and gutter, the size and shape must be considered and the amount of materials estimated.

Combined curb and gutter is usually 12″ high at the outside edge (including pavement thickness), 24″ to 30″ wide and 6″ to 7½″ thick.

Integral curb is formed as a part of the concrete pavement and is usually 6″x6″x7″ in size, as shown in the illustration.

Separate concrete curb is usually 6″ wide at the top, 8″ to 9″ wide at the bottom, and 24″, 30″ or 36″ high.

Forms for Concrete Curb and Gutter.—When placing integral concrete curb, two cement masons and a helper should set forms for 220 to 240 lin. ft. of curb per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	7.0	$.....	$.....	$6.50	$45.50
Helper	3.5	.....	.....	5.00	17.50
Cost per 100 lin. ft.	10.5		$.....		$63.00
Cost per lin. ft.			.....		.63

When placing wood forms for separate concrete curb, two cement masons and a helper should set forms for 100 to 110 lin. ft. of 24″ curb per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	15.0	$.....	$.....	$6.50	$ 97.50
Helper	7.5	.....	.....	5.00	37.50
Cost per 100 lin. ft.	22.5		$.....		$135.00
Cost per lin. ft.			.....		1.35

Two cement masons and a helper should set forms for 90 to100

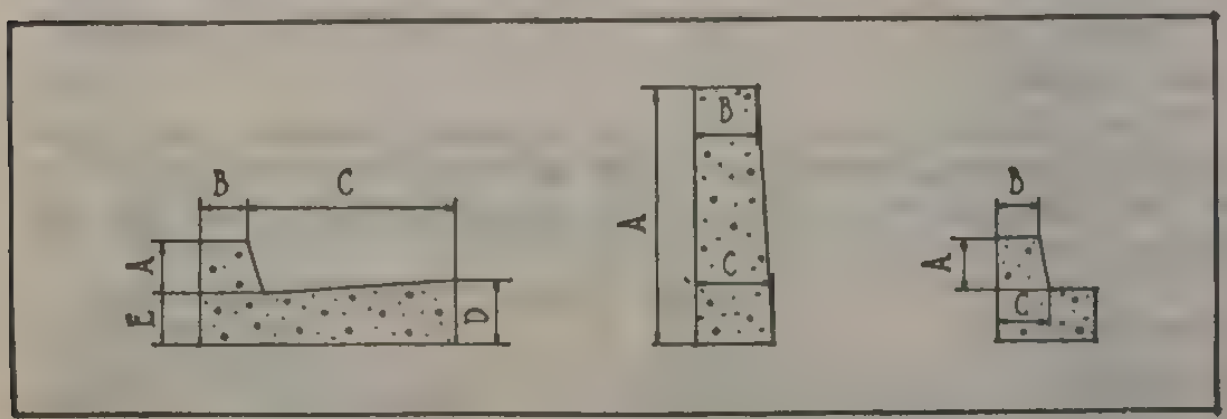
lin. ft. of 30" concrete curb per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	17.0	$.....	$.....	$6.50	$110.50
Helper	8.5	.....	.....	5.00	42.50
Cost per 100 lin. ft.	25.5		$.....		$153.00
Cost per lin. ft.			.....		1.53

When setting wood forms for combined concrete curb and gutter, two cement masons and a helper should set forms for 100 to 110 lin. ft. of curb and gutter per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	15.50	$.....	$.....	$6.50	$100.75
Helper	7.75	.....	.....	5.00	38.75
Cost per 100 lin. ft.	23.25		$.....		$139.50
Cost per lin. ft.			.....		1.395

Wood forms for concrete curb and gutter are ordinarily built of 2" lumber. Including all bracing, it requires 2¼ to 2½ ft. of lumber, b.m. per sq. ft. of forms. If the forms are wider than one plank width the carpenters usually claim making up the forms. This cost will run from 10 to 15 cents per sq. ft. and should be added to the above setting costs, taking into consideration the number of uses which are expected to be obtained from the forms. These forms may be used many times if properly taken care of.



Combined Curb and Gutter | Separate Concrete Curb | Integral Concrete Curb and Gutter

Cement, Sand and Stone Required Per 100 Lin. Ft. of Integral Concrete Curb

A	B	C	1:1½:3			1:2:3			1:2:4		
			Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.
6″	6″	7″	7.64	0.42	0.85	6.96	0.52	0.77	6.04	0.45	0.89

Cement, Sand and Stone Required Per 100 Lin. Ft. of Separate Concrete Curb

A	B	C	1:2:3			1:2:4			1:2½:5		
			Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.
24″	6″	8″	30.00	2.25	3.34	26.00	1.95	3.86	21.48	2.00	3.98
30″	6″	8½″	38.92	2.91	4.31	33.80	2.52	4.99	27.76	2.58	5.15
36″	6″	9″	48.48	3.61	5.35	42.00	3 12	6 18	34.44	3.19	6.39

Cement, Sand and Stone Required Per 100 Lin. Ft. of Combined Concrete Curb and Gutter

A	B	C	D	E	1:2:3			1:2:4			1:2½:5		
					Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.
6″	6″	18″	7 ″	6″	34.80	2.60	3.85	30.20	2.25	4.45	24.80	2.30	4.60
6″	6″	24″	7½″	6″	43.20	3.22	4.77	37.40	2.79	5.52	30.72	2.85	5.70

Cement, Sand and Stone Required Per Sq. Yd. of Concrete Pavement

Thickness	Per Sq. Yd. 1:1½:3			Per Sq. Yd. 1:2:3			Per Sq. Yd. 1:2:3½		
	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.
6 ″	1.2734	.0700	.1417	1.1596	.0856	.1283	1.0728	.0800	.1410
7 ″	1.4856	.0817	.1653	1.3532	.1011	.1497	1.2520	.0933	.1614
7½″	1.5563	.0856	.1731	1.4172	.1059	.1568	1.3112	.0977	.1690
7¾″	1.6270	.0894	.1810	1.4818	.1107	.1639	1.3710	.1022	.1767
8 ″	1.6978	.0933	.1889	1.5464	.1155	.1711	1.4308	.1067	.1844
8½″	1.7713	.0972	.1965	1.6120	.1205	.1785	1.4900	.1110	.1920
8¾″	1.8392	.1011	.2046	1.6758	.1252	.1854	1.5498	.1155	.2017
9 ″	1.9100	.1050	.2125	1.7396	.1300	.1923	1.6096	.1200	.2115

Cement, Sand and Stone Required Per Lin. Ft. of Concrete Pavement

Thickness	Per Lin. Ft. 18′–0″ Wide 1:1½:3			Per Lin. Ft. 18′–0″ Wide 1:2:3			Per Lin. Ft. 18′–0″ Wide 1:2:3½		
	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.
6 ″	2.5467	.1400	.2833	2.3192	.1732	.2604	2.1456	.1600	.2820
7 ″	2.9712	.1634	.3306	2.7064	.2022	.2994	2.5040	.1866	.3228
7⅛″	3.1126	.1712	.3462	2.8344	.2120	.3130	2.6224	.1954	.3380
7⅜″	3.2540	.1788	.3620	2.9636	.2215	.3276	2.7420	.2044	.3534
8 ″	3.3956	.1866	.3778	3.0928	.2310	.3422	2.8616	.2134	.3688
8⅛″	3.5426	.1944	.3930	3.2240	.2410	.3570	2.9800	.2220	.3840
8¾″	3.6784	.2022	.4092	3.3516	.2505	.3738	3.0996	.2310	.4035
9 ″	3.8200	.2100	.4250	3.4792	.2600	.3906	3.2192	.2400	.4230

Sq. Yds. of Concrete Pavement Obtainable from One Cu. Yd. of Concrete

Thickness Inches	Number Sq. Yds.	Thickness Inches	Number Sq. Yds.
4	9	8	4½
4½	8	8⅓	4⅓
5	7	8½	4¼
5½	6½	8⅔	4
6	6	9	4
6½	5½	9½	3¾
7	5	10	3½
7⅛	4 9/10	10½	3½
7½	4 8/10	11	3¼
7⅔	4 7/10	11½	3
		12	3

Mixing and Placing Concrete for Curb and Gutter.—Concrete for curb and gutter is usually placed in small quantities using a 3½-S or 6-S mixer of ½ to 1 sack capacity.

On account of the small amount of concrete required and the labor involved in placing it between narrow forms, a gang of men are unable to mix and place as much concrete as on floors or foundations.

A crew of 3 men should mix and place about 1 cu. yd. of concrete an hr. at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	3	$.....	$.....	$5.00	$15.00

Mixing and Placing Finish Top for Concrete Curb and Gutter.—When mixing and placing finish top for concrete curb and gutter, a gang of 4 men will mix materials and finish 550 to

650 sq. ft. of curb or combined curb and gutter per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	1.33	$.....	$.....	$6.50	$ 8.65
Helper	1.33	.....	.....	5.00	6.65
Labor	2.67	.....	.....	5.00	13.35
Cost per 100 sq. ft.	5.33		$.....		$28.65
Cost per sq. ft.			.....		.287

Concrete Roads and Pavements

Concrete roads and pavements are usually thicker in the center than at the sides, so it will be necessary to obtain the average thickness of the pavement when estimating quantities of concrete materials.

Some pavements have uniform thickness, others have uniform center section and thickened edges. In each case the area of the cross section must be determined and this is multiplied by the length to find the volume of concrete required.

Labor Placing Edge Forms for Concrete Paving.—Wood edge forms for concrete paving usually consist of 2″ plank, of a width equal to the slab thickness, set to line and grade, secured to wood stakes and braced.

Two cement masons and a helper should set to line and grade from 250 to 300 lin. ft. of edge forms per 8-hr. day at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	3.0	$.....	$.....	$6.50	$19.50
Helper	1.5	.....	.....	5.00	7.50
Cost per 100 lin. ft.	4.5	.....	$.....		$27.00
Cost per lin. ft.			.....		.270

The above costs are based on the forms being straight or set to long radius curves. If sharp curves are required the form must be either made from 1 inch boards or the back of a 2″ plank must be kerfed and in both cases the stakes must be set much closer together.

Concrete paving edge forms set to short radius curves will cost 50 to 100 percent more than straight forms.

Mixing and Placing Concrete Pavements.—The labor cost of mixing and placing concrete pavements will vary with the size of the mixer, the method used in feeding and discharging same, access to materials, length of haul, etc.

Where a regular paving mixer is used having a skip loader that may be loaded by trucks or tractors and having an ex-

tension boom for discharging the concrete, minimum labor costs may be obtained, as it requires only a small crew of men to operate the mixer.

On the other hand if the mixer is fed by wheelbarrows and the concrete is wheeled from the mixer in tractor carts, the labor costs will run higher, so the method to be used should be known if accurate labor costs are to result.

The length of mixing time should also be considered because the strength of concrete is dependent upon the amount of mixing water used and the length of time the concrete remains in the mixer. Many engineers specify the concrete must remain in the mixer 1½ to 2 minutes, so when these conditions prevail, the output is restricted but the quality of the concrete is increased.

If the concrete must remain in the mixer 1½ to 2 minutes, a fair average for a job will be 25 to 30 batches of concrete an hour and the following costs are based on that assumption.

Using a 11-S mixer fed by hand with the concrete taken from the mixer in wheelbarrows or concrete buggies, the labor per cu. yd. of concrete should cost as follows:

	Hours	Rate	Total	Rate	Total
Mixer engineer	0.09	$.....	$.....	$6.75	$0.61*
Labor	1.65	.....	.....	5.00	8.25
Cost per cu. yd.	1.74		$.....		$8.86

If the mixer is fed by hand and the concrete taken from the mixer in power buggies, the labor per cu. yd. should cost as follows:

	Hours	Rate	Total	Rate	Total
Mixer engineer	0.09	$.....	$.....	$6.75	$0.61*
Labor	1.30	.....	.....	5.00	6.50
Power buggy operator	0.09	.....	.....	5.00	.45
Cost per cu. yd.	1.48		$.....		$7.56

If a 28-S mixer is fed by batch trucks and the concrete discharged from the mixer on a boom spout or bucket, the labor per cu. yd. should cost as follows:

	Hours	Rate	Total	Rate	Total
Mixer engineer	0.04	$.....	$.....	$6.75	$0.27
Labor	0.24	.....	.....	5.00	1.20
Cost per cu. yd.	0.28		$.....		$1.47

Placing Ready-mix Concrete Pavements.—When using ready-mix concrete the labor cost of placing concrete pavements is

*Add only if required.

somewhat less than when using a small mixer due to the elimination of the mixing crew.

On small jobs, using ready-mix concrete and wheeling the concrete into place with wheelbarrows the labor per cu. yd. of concrete should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	1.2	$.....	$.....	$5.00	$6.00

If ready-mix concrete can be discharged from truck directly into place without wheeling, deduct 0.7-hr. labor time.

On larger jobs, containing 100 cu. yds. or more of concrete, better organization may be obtained and lower costs are the result. Assuming a pavement containing from 100 to 200 cu. yds. of ready-mixed concrete wheeled into place with buggies the labor per cu. yd. of concrete should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	0.6	$.....	$.....	$5.00	$3.00

If power buggies are used to transport ready-mixed concrete from truck or hopper to place of deposit it will result in a saving of about 0.20-hr. labor time per cu. yd. of concrete.

If ready-mix concrete can be discharged from truck directly into place without wheeling, deduct 0.4-hr. labor time.

Finishing Concrete Pavements.—Finishing concrete pavements usually consists of a series of operations performed in the following sequence: strike-off and consolidation, floating, straightedging, belting, brooming and edging.

Strike-off and consolidation is accomplished in the following manner: after concrete is placed and roughly leveled, a strike board or tamping templet is passed over the surface, with a sawing motion, moving in the direction in which the work is progressing. The surface is struck off slightly above grade to allow for compaction during tamping and a slight excess of concrete is kept in front of the cutting edge of the strike board during the entire operation. The entire surface is then tamped until the required compaction is obtained.

As soon as possible after striking off and tamping, the surface is further smoothed and consolidated by floating, using long-handled floats and lapping the strokes at least one-half.

After floating is completed and the excess water and laitance is removed the surface is tested with a long straightedge and all surface irregularities are corrected, consolidated and floated.

After straightedging and correcting, when most of the water sheen has disappeared and just before the concrete becomes non-

plastic the surface is belted using a strip of canvas or canvas-rubber composition at least 6 inches in width. The belt is moved across the surface with short strokes transverse to the pavement centerline and at the same time advancing along the pavement.

After belting, the pavement is given a broom finish. Using a long-handled push broom, the broom is drawn from the pavement centerline to the edge, with adjacent strokes slightly overlapping and producing uniform corrugations about $\frac{1}{16}$ inch in depth.

Finally, after the previous operations are completed but before the concrete has taken its initial set, the edges of the slab are neatly finished with an edger.

Labor Finishing Concrete Pavements.—Assuming an 8 inch concrete pavement being placed at the rate of 25 cu. yds. per hr. or 1,013 sq. ft. per hr. a crew of 12 to 14 cement masons should be able to keep up with the pour and perform all the above described finishing operations at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Cement mason	1.2	$.....	$.....	$6.50	$ 7.80
Helper	.4	.....	.....	5.00	2.00
Cement mason foreman	.1	.....	.....	6.85	.69
Cost per 100 sq. ft.	1.7		$.....		$10.49
Cost per sq. ft.			.....		.105

The above costs are based on a job which will run from 7,500 to 8,500 sq. ft. per 8-hr. day. On smaller jobs the costs will increase from 20 to 25 percent because the finishing crew will be cut down in size and each man will have to perform several of the operations, thereby losing time in changing from one job to another.

CHAPTER X

CONCRETE MASONRY AND PARTITION UNITS; TILE AND CONCRETE STORAGE BINS AND SILOS; CONCRETE JOISTS AND PRECAST CONCRETE SLABS; PRESTRESSED CONCRETE; AND PRECAST AND POURED GYPSUM FLOORS AND ROOF SLABS

Concrete masonry materials, commonly termed "Concrete Block" or "Concrete Brick" are extensively used in all parts of the country for exterior and interior bearing walls, interior partitions, floor and roof fillers, etc.

They are also widely used for backing up face or press brick as well as for backing up common brick when used as a wall facing. They are used both for bearing walls on wall bearing structures and for curtain walls in steel or reinforced concrete frame structures.

Within the past few years the use of concrete masonry has increased greatly. This is partly due to the lower labor cost of handling and setting the larger concrete units in comparison with common brick, when used as a back-up material.

The term concrete masonry is applied to block, brick or tile building units molded from concrete and laid by masons into a wall, the same as clay brick or tile.

The concrete is made by mixing portland cement with [illegible] and other suitable materials, such as sand, gravel, crushed [illegible] bituminous or anthracite cinders, burned clay or shale, blast furnace slag, pumice, perlite and vermiculite. Fly ash is also being used in the manufacture of some concrete blocks.

Concrete masonry units should always be manufactured in a cement products plant where facilities for manufacturing, curing, etc., are uniform so as to obtain high quality products.

The quality of all concrete masonry units should conform to the standards set by the American Society for Testing and Materials in their standard specifications for concrete masonry units and concrete brick.

Weight of Concrete Masonry.—A $7\frac{5}{8}$"x$7\frac{5}{8}$"x$15\frac{5}{8}$" hollow load-

bearing concrete block weighs from 40 to 50 lbs. when made from heavyweight aggregate and from 25 to 35 lbs. when made from lightweight aggregate. Heavyweight aggregates are sand, gravel, crushed stone, air-cooled slag, etc. Lightweight aggregates are coal cinders, expanded shale, clay or slag, pumice, perlite, vermiculite, etc.

Estimating Quantities of Concrete Brick.—Concrete brick are manufactured, throughout the country generally, in the modular size of 2¼" x 3⅝" x 7⅝". In some localities, additional sizes are available as follows: Jumbo brick, 3⅝" x 3⅝" x 7⅝"; double brick, 4⅞" x 3⅝" x 7⅝"; and Roman brick, 1⅝" x 3⅝" x 11⅝" and 1⅝" x 3⅝" x 15⅝".

They should be estimated by the sq. ft. of wall of any thickness or by the cu. ft., if all wall thicknesses are combined. For instance, if there are only 8" walls in the job, it will be satisfactory to take the number of sq. ft. of walls but if the job contains 8", 12" and 16" walls, then it will be easier and more satisfactory to reduce the quantities to cu. ft. and multiply by a certain number of brick per cu. ft. of wall.

The number of concrete brick required per square or cubic foot of wall will vary with the size of brick and width of mortar joint used. Concrete brick sizes and widths of mortar joints have been standardized so that they will lay up to an even multiple of the 4-inch module.

All concrete brick units are 3⅝" thick, which together with a ⅜" mortar back joint equal the modular thickness of 4 inches. Since there is always one less mortar joint than brick, in walls of multiple brick thickness, the actual wall thickness will always be ⅜" less than the modular 4 inches; i.e. 3⅝", 7⅝", 11⅝", 15⅝", etc.

In drawing plans, some architects give actual wall thickness dimensions, while others use nominal dimensions. For estimating purposes, nominal dimensions should be used, i.e. 4", 8", 12", etc., to facilitate computations.

In measuring the plans and listing the quantities of brick required, always take exact measurements for length and height and deduct all openings in full. Do not count corners twice but have your estimate show as accurately as possible the actual number of brick required to complete the job. For unexposed backup work, add 1 to 2 percent for waste. For exposed brickwork, add 3 to 5 percent for waste.

Modular Size Concrete Brick

Modular size concrete brick, 2¼"x3⅝"x7⅝" are laid so that 3 courses of brick, with 5/12" mortar joints, builds 8" in height,

and the 7⅝" length, plus ⅜" mortar joint, makes a total length of 8" laid in the wall. In other words, 3 brick lay 8"x8", or 64 sq. in. so it requires 6¾ or 6.75 brick per sq. ft. of wall of nominal 4" thickness.

Jumbo brick are 3⅝"x3⅝"x7⅝" in size and are laid so that 3 courses of brick, with ⅜" mortar joints, builds 12" in height, and the 7⅝" length, plus ⅜" mortar joint, makes a total length of 8" laid in the wall. One jumbo brick lays 32 sq. in. in the wall or it requires 4.5 brick per sq .ft. of wall of nominal 4" thickness.

Double brick are 4⅞"x3⅝"x7⅝" in size, so that 3 courses of brick, with 11/24" mortar joint builds 16" high, and the 7⅝" length, plus ⅜" mortar joint, makes a total length of 8" in the wall, or one brick lays 42.67 sq. in. in the wall or it requires 3.4 brick per sq. ft. of wall of nominal 4" thickness.

Roman size brick are 1⅝"x3⅝"x11⅝" and 1⅝"x3⅝"x15⅝" and are laid so that 6 courses of brick, with ⅜" mortar joints, builds 12" in height, and the 11⅝" or 15⅝" lengths, plus ⅜" mortar joints, makes a total length of 12" or 16" respectively laid in the wall. One nominal 12" brick lays 24 sq. in. in the wall or it requires 6 brick per sq. ft. of wall of nominal 4" thickness. One nominal 16" brick lays 32 sq. in. in the wall or it requires 4.5 brick per sq. ft. of wall of nominal 4" thickness.

The number of modular size brick per sq. ft. of wall of various thicknesses is as follows:

	1-Brick or 4" Wall	2-Bricks or 8" Wall	3-Bricks or 12" Wall*
2¼"x3⅝"x7⅝"	6.75	13.50	20.25
3⅝"x3⅝"x7⅝"	4.50	9.00	13.50
4⅞"x3⅝"x7⅝"	3.40	6.80	10.20
1⅝"x3⅝"x11⅝"	6.00	12.00	18.00
1⅝"x3⅝"x15⅝"	4.50	9.00	13.50

*Use this column for number of brick required per cu. ft. of wall. No allowance is included for waste in above quantities.

Mortar for Concrete Masonry.—For laying masonry walls subject to average conditions of exposure, use a mortar made in the proportions of 1 volume of masonry cement* and between 2 and 3 volumes of damp, loose mortar sand; or 1 volume of portland cement and between 1 and 1¼ volumes of hydrated lime or lime putty and between 4 and 6 volumes of damp, loose mortar sand.

Walls which will be subjected to extremely heavy loads, severe winds, earthquakes, serious frost action, or other conditions requiring extra wall strength, should be laid with a mortar made of 1 volume masonry cement plus 1 volume portland ce-

ment and between 4 and 6 volumes of damp, loose mortar sand; or 1 volume of portland cement, to which may be added up to ½ volume of hydrated lime or lime putty, and between 2 and 3 volumes of damp, loose mortar sand.

Cost of One Cubic Yard Cement Mortar for Concrete Masonry

1 volume masonry cement and 3 volumes loose mortar sand.

	Rate	Total	Rate	Total
9 sacks masonry cement	$.....	$.....	$1.60	$14.40
1.00 cu. yd. sand	.....	.....	4.25	4.25
Cost per cu. yd.		$.....		$18.65
Cost per cu. ft.		.....		.692

1 volume portland cement: 1 volume hydrated lime: 6 volumes loose mortar sand.

	Rate	Total	Rate	Total
4.5 sacks portland cement.	$.....	$.....	$1.80	$ 8.10
196 lbs. hydrated lime	.....	.....	.02	3.92
1.00 cu. yd. sand	.....	.....	4.25	4.25
Cost per cu. yd.		$.....		$16.27
Cost per cu. ft.		.....		.603

1 volume portland cement; 2 volumes hydrated lime or lime putty; 9 volumes loose mortar sand.

	Rate	Total	Rate	Total
3 sacks portland cement	$.....	$.....	$1.80	$ 5.40
261 lbs. hydrated lime	.....	.....	.02	5.22
1.00 cu. yd. sand	.....	.....	4.25	4.25
Cost per cu. yd.		$.....		$14.87
Cost per cu. ft.		.....		.551

1 volume masonry cement: 1 volume portland cement: 6 volumes loose mortar sand.

	Rate	Total	Rate	Total
4.5 sacks masonry cement.	$.....	$.....	$1.60	$ 7.20
4.5 sacks portland cement.	.....	.....	1.80	8.10
1.00 cu. yd. sand	.....	.....	4.25	4.25
Cost per cu. yd.		$.....		$19.55
Cost per cu. ft.		.....		.724

1 volume portland cement: ½-volume hydrated lime: 3 volumes loose mortar sand.

	Rate	Total	Rate	Total
7.83 sacks portland cement	$.....	$.....	$1.80	$14.09
90 lbs. hydrated lime	.....	.....	.02	1.80
0.86 cu. yd. sand	.....	.....	4.25	3.66
Cost per cu. yd.		$.....		$19.55
Cost per cu. ft.		.....		.724

Quantity of Mortar Required to Lay 1,000 Concrete Brick of Various Sizes

Width of Bed Joint	Thickness of Wall: 1 Brick or 4″ Wall	2 Bricks or 8″ Wall	2 Bricks or 8″ Backup	3 Bricks or 12″ Wall
	Modular Size Brick, $2\frac{1}{4}$″x$3\frac{5}{8}$″x$7\frac{5}{8}$″			
5/12″	9.64 cu. ft.	12.19 cu. ft.	14.73 cu. ft.	13.01 cu. ft.
	Jumbo Brick, $3\frac{5}{8}$″x$3\frac{5}{8}$″x$7\frac{5}{8}$″			
3/8″	10.06 cu. ft.	13.88 cu. ft.	17.70 cu. ft.	15.15 cu. ft.
	Double Brick, $4\frac{7}{8}$″x$3\frac{5}{8}$″x$7\frac{5}{8}$″			
11/24″	12.68 cu. ft.	17.77 cu. ft.	22.86 cu. ft.	19.47 cu. ft.
	Roman Brick, $1\frac{5}{8}$″x$3\frac{5}{8}$″x$11\frac{5}{8}$″			
3/8″	11.79 cu. ft.	14.65 cu. ft.	.....	.....
	Roman Brick, $1\frac{5}{8}$″x$3\frac{5}{8}$″x$15\frac{5}{8}$″			
3/8″	15.25 cu. ft.	19.07 cu. ft.	.....	.....

All end and back joints figured $\frac{3}{8}$″. Quantities include 10 percent for waste.

Labor Handling and Laying Concrete Brick

The labor cost of handling and laying concrete brick will vary with the size of brick, kind of mortar, class of work, thickness of walls, number of openings, etc.

On buildings having long straight walls without many openings, such as basement walls, garages, factories, etc., a mason should lay 800 to 900 modular size concrete brick, $2\frac{1}{4}$″x$3\frac{5}{8}$″x$7\frac{5}{8}$″, per 8-hr. day, while on dwellings and other structures having 8″ walls, cut up with numerous openings, pilasters, etc., a mason should lay 650 to 700 brick per 8-hr. day.

Cost of 1,000 Modular Size Concrete Brick, $2\frac{1}{4}$″x$3\frac{5}{8}$″x$7\frac{5}{8}$″, Laid in 8″ Walls

	Hours	Rate	Total	Rate	Total
1,000 brick		$.....	$.....	$50.00	$50.00
12.19 cu. ft. 1:1:6 mortar		.....	.....	.603	7.35
Mason	11.8	.....	.....	7.10	83.78
Labor	8.8	.....	.....	5.00	44.00
Cost per 1,000 brick...	20.6		$.....		$185.13

Cost of 1,000 Modular Size Concrete Brick, $2\frac{1}{4}$″x$3\frac{5}{8}$″x$7\frac{5}{8}$″, Laid in 12″ Walls

	Hours	Rate	Total	Rate	Total
1,000 brick		$.....	$.....	$50.00	$50.00
13.01 cu. ft. 1:1:6 mortar		.....	.....	.603	7.85
Mason	9.5	.....	.....	7.10	67.45
Labor	9.5	.....	.....	5.00	47.50
Cost per 1,000 brick...	19.0		$.....		$172.80

Above costs based on flush cut mortar joints. For struck joints, add $\frac{1}{2}$-hr. mason time per 1,000 brick.

Estimate the labor cost of laying concrete face brick the same as given for "Face Brick," under "Brick Masonry."

On similar work, using jumbo brick, 3⅝"x3⅝"x7⅝", a mason should lay 675 to 775 brick per 8-hr. day in 12" walls and 550 to 600 brick per day in 8" walls.

Using double brick, 4⅛"x3⅝"x7⅝", a mason should lay 450 to 550 brick per 8-hr. day in 12" walls and 375 to 425 brick per day in 8" walls.

Roman size concrete brick, 1⅝"x3⅝"x11⅝" or 1⅝"x3⅝"x15⅝", are used only for facing or in 8" walls. The labor cost of handling and laying these brick will vary considerably, depending upon the type of joint treatment, flush cut, V-tooled or concave, struck or weathered, raked out, etc.

On average work with flush cut joints, a mason should lay 300 to 350 nominal 12" Roman brick per 8-hr. day or 225 to 265 nominal 16" Roman brick per 8-hr. day. For tooled, struck, weathered or raked out joints, reduce the above production quantities 8 to 12 percent.

Concrete Blocks and Partition Units

Concrete blocks and partition units are manufactured in two weights of concrete, one weighing approximately 145 lbs. per cu. ft. (sand, pebbles, crushed stone or slag aggregates) and another of lighter weight concrete weighing about 100 lbs. per cu. ft. of burned clay, cinder, processed slag, pumice, perlite or vermiculite aggregates.

These two types of units may be used interchangeably for all purposes although the lightweight units afford a saving of weight to secure economy in design; they afford increased heat and sound insulation and provide a satisfactory nailing base without the use of grounds.

Estimating the Quantity of Concrete Blocks and Partition Units.—Concrete blocks and partition units should be estimated by the square foot of wall of any thickness and then multiplied by the number of blocks per 100 sq. ft. as given in the following tables.

When estimating quantities, always take exact measurements and do not count corners twice.

Make deductions in full for all openings, regardless of size. The result will be the actual number of sq. ft. or number of blocks required for the job.

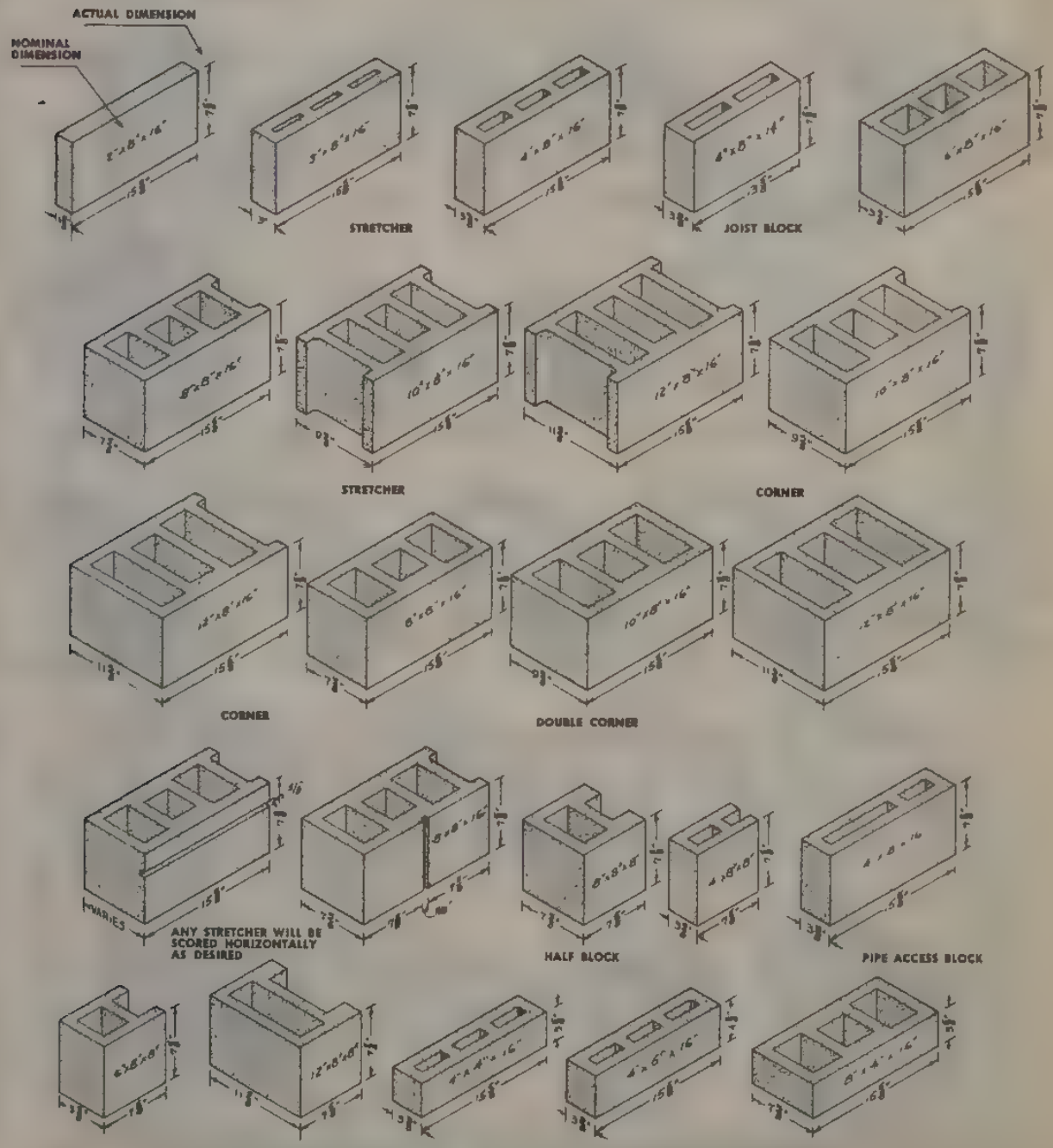
Mortar.—The same kind of mortar should be used in laying concrete blocks as given for Concrete Brick.

When laying up exterior walls, face shell bedding shall be used with complete coverage of face shells. Furrowing of the mortar shall not be permitted. Extruded mortar shall be cut off flush with face of wall and the joints firmly compacted, after the mortar has stiffened somewhat.

Tooling is essential in producing tight mortar joints. Mortar has a tendency to shrink slightly and may pull away from the masonry units causing fine, almost invisible cracks at the junction of mortar and masonry units.

Sizes and Weights of Concrete Masonry Units

Concrete masonry units are usually made with standard modular face dimensions $7\frac{5}{8}$" high and $15\frac{5}{8}$" long and are available in

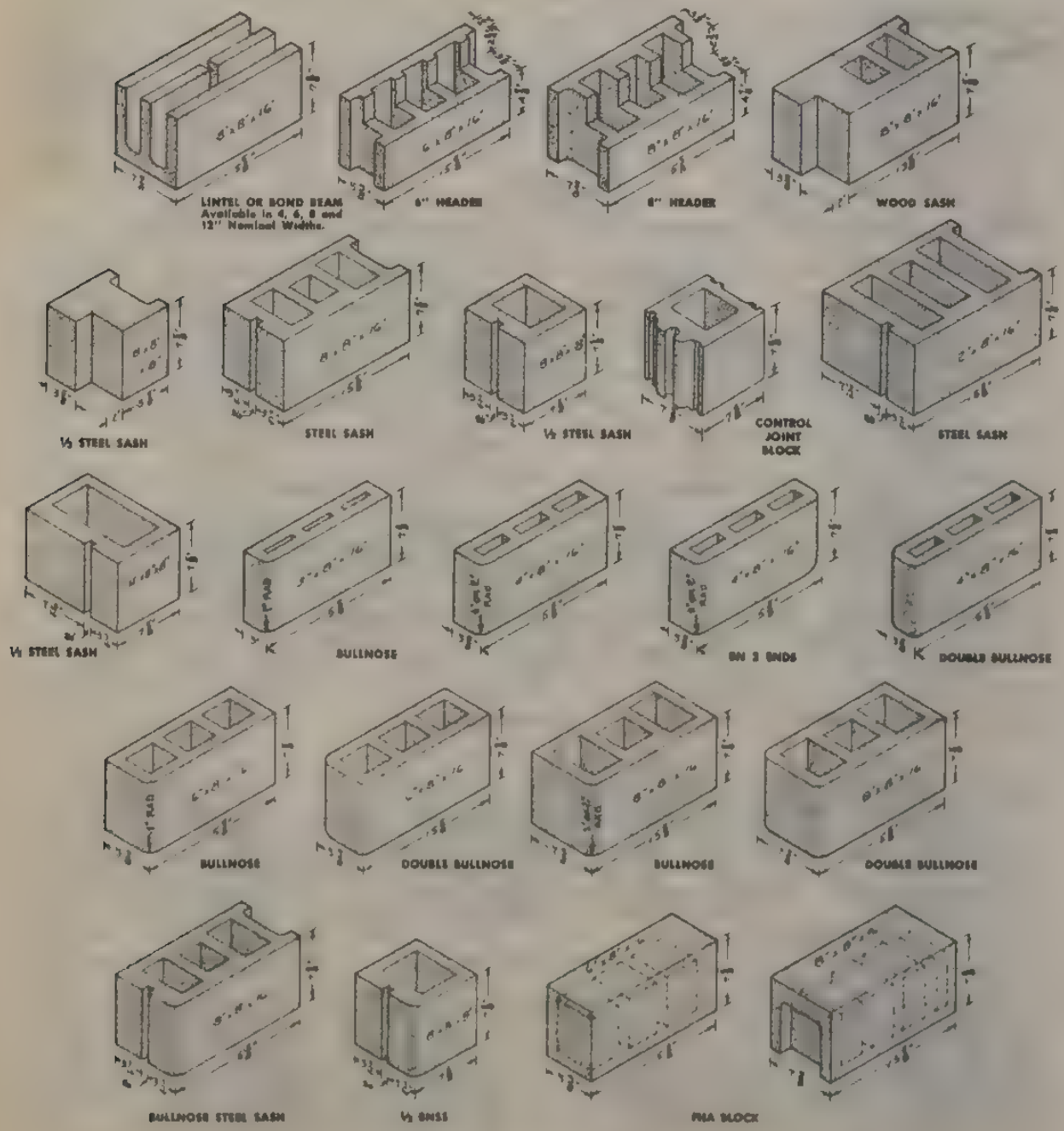


Sizes and Shapes of Concrete Building Units.

thicknesses $\frac{3}{8}$" less than the nominal 3", 4", 5", 6", 8", 10" and 12" thickness.

When laid up with $\frac{3}{8}$" mortar joints the units are 8" high and 16" long, requiring 112.5 units per 100 sq. ft. of wall, not including allowance for waste and breakage.

Hollow and solid partition and furring units have nominal thickness of 2", 3", 4", 5", 6" and 8".



Sizes and Shapes of Concrete Building Units.

Hollow and solid load bearing units have nominal thickness of 4", 6", 8", 10" and 12" and are also available in half lengths.

Standard specials such as steel and wood sash jambs, bullnose and closures are also available in full and half lengths.

There are also many special sizes available on special order but are not usually stocked by the manufacturing plants.

The accompanying illustration shows many of the special sizes and shapes available upon special order.

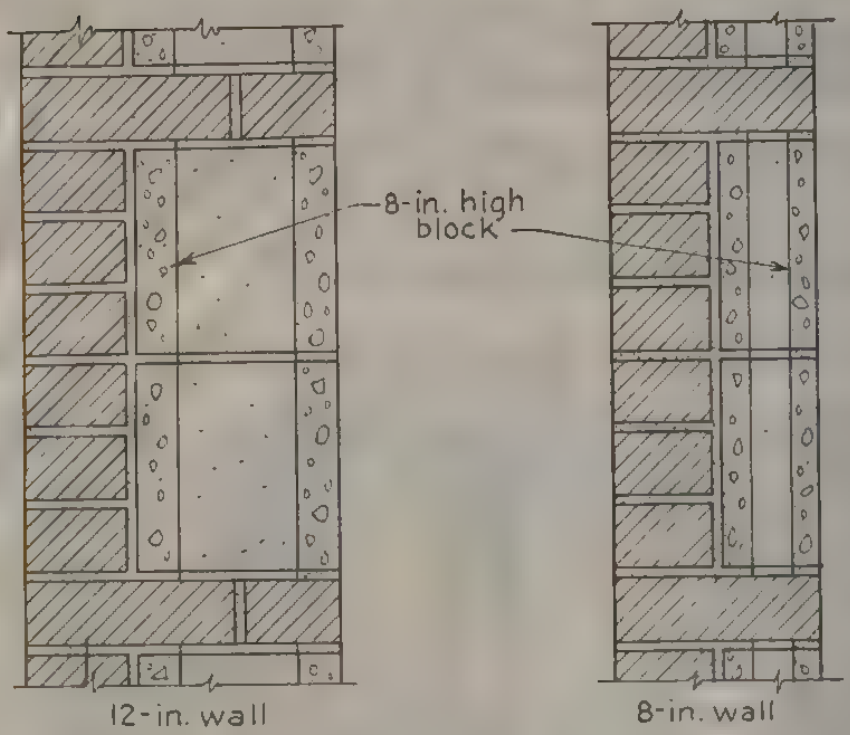
Sizes, Weights and Quantities of Load-Bearing Concrete Blocks and Tile

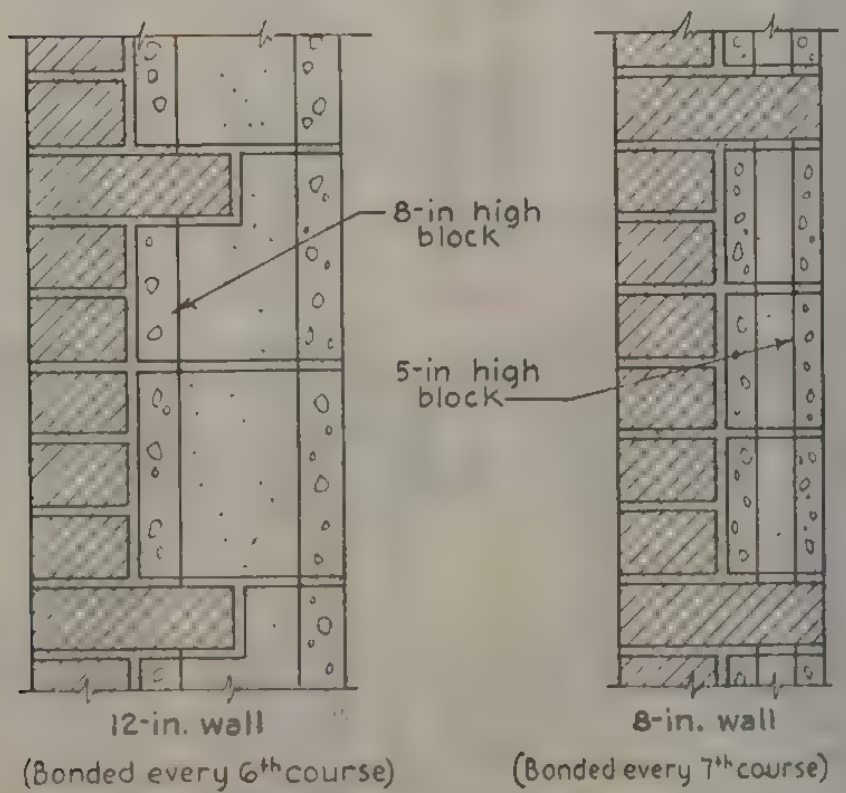
Actual Size and Description of Units	Wall Thickness	Approx. Weight Lbs. Hvy. Wt. Units	Approx. Weight Lbs. Light Wt. Units	No. Units 100 Sq. Ft. of Wall	Cu. Ft. Mortar 100 Sq. Ft. of Wall
3⅝"x4⅞"x11⅝"	4"	11-13	8-10	225	8.0
5⅝"x4⅞"x11⅝"	6"	17-19	12-14	225	8.5
7⅝"x4⅞"x11⅝"	8"	22-24	14-16	225	9.0
3⅝"x7⅝"x11⅝"	4"	17-19	12-14	150	6.0
5⅝"x7⅝"x11⅝"	6"	26-28	17-19	150	6.5
7⅝"x7⅝"x11⅝"	8"	33-35	21-23	150	7.0
9⅝"x7⅝"x11⅝"	10"	42-45	27-29	150	7.5
11⅝"x7⅝"x11⅝"	12"	48-51	29-31	150	8.0
3⅝"x3⅝"x15⅝"	4"	12-14	9-10	225	9.0
5⅝"x3⅝"x15⅝"	6"	17-19	11-13	225	9.5
7⅝"x3⅝"x15⅝"	8"	22-24	14-16	225	10.0
3⅝"x7⅝"x15⅝"	4"	23-25	16-18	112.5	5.0
5⅝"x7⅝"x15⅝"	6"	35-37	24-26	112.5	5.0
7⅝"x7⅝"x15⅝"	8"	45-47	29-31	112.5	6.0
9⅝"x7⅝"x15⅝"	10"	57-60	36-38	112.5	6.5
11⅝"x7⅝"x15⅝"	12"	64-67	40-42	112.5	7.0

Sizes, Weights and Quantities of Concrete Partition Tile

Actual Size and Description of Units	Wall Thickness	Approx. Wt. Light Wt. Units Lbs.	No. Units 100 Sq. Ft. Wall	Cu. Ft. Mortar 100 Sq. Ft. Wall*
3⅝"x7⅝"x11⅝"	4"	12-14	150	6.0
5⅝"x7⅝"x11⅝"	6"	17-19	150	6.5
7⅝"x7⅝"x11⅝"	8"	21-23	150	7.0
1⅝"x7⅝"x15⅝"	2"	11-12	112.5	3.0
3⅝"x7⅝"x15⅝"	4"	16-18	112.5	5.0
5⅝"x7⅝"x15⅝"	6"	24-26	112.5	5.0
7⅝"x7⅝"x15⅝"	8"	29-31	112.5	6.0

*Actual mortar quantities figure out about half those given in the above table but experience on the job shows that considerable more mortar is required, due to waste, droppings, etc.





Examples of Concrete Masonry Used as Backup for Brick.

Labor Laying Concrete Masonry

The labor cost of laying the various types and sizes of concrete blocks and tile will vary with the size and weight of the blocks, the class of work, whether long straight walls or walls cut up with numerous openings, etc.

Labor costs will also vary, depending upon whether or not the blocks are laid above or below grade, as basement walls usually proceed faster than exposed work above grade.

It is usually more economical to use lightweight units, even though they cost a few cents more per piece, as a mason can handle and lay them with less effort. In some localities union regulations require two masons to work together where the blocks weigh more than 35 pounds each.

Where concrete blocks are used for exterior or interior facing walls, with the blocks carefully laid to a line and in various patterns and with neatly tooled mortar joints, the labor costs will run considerably higher than on straight structural walls.

The quantities given in the following tables are based on average conditions with blocks laid in 1 :1 :6 cement-lime mortar. If portland cement mortar is used above grade, reduce daily output about 5 percent.

All quantities are based on the output of one mason and one laborer or hod carrier per 8-hr. day. If hoisting engineer time is required, add about ¼-hr. per 100 sq. ft.

Number of Concrete Partition Tile Laid Per 8-Hr. Day By One Mason

Partition Tile

Actual Size of Units	Wall Thickness	Number Light-weight Units* Laid per 8-Hour Day	Hours per 100 Pieces Mason	Labor
3⅝"x7⅝"x11⅝"	4"	195-215	3.9	3.9
5⅝"x7⅝"x11⅝"	6"	175-195	4.3	4.3
7⅝"x7⅝"x11⅝"	8"	155-175	4.8	4.8
1⅝"x7⅝"x15⅝"	2"	180-200	4.2	4.2
3⅝"x7⅝"x15⅝"	4"	190-210	4.0	4.0
5⅝"x7⅝"x15⅝"	6"	170-190	4.5	4.5
7⅝"x7⅝"x15⅝"	8"	150-170	5.0	5.0

*If heavyweight concrete units are used, decrease above quantities 10 percent and increase labor hours accordingly.

Mortar Joints.—Hollow concrete blocks or tile should be laid with broken joints to secure the maximum resistance to moisture and heat penetration. Sufficient mortar is spread on the inner and outer shell bed and end joints to cover and to provide a joint of the required thickness when pressed into place. Solid units, brick, etc., are laid in solid beds.

Number of Concrete Building Units Laid Per 8-Hr. Day by One Mason

Actual Size of Units	Wall Thickness	Number Lightweight Units* Laid per 8-Hour Day	Hours per 100 Pieces Mason	Labor
3⅝"x4⅞"x11⅝"	4"	215-235	3.5	3.5
5⅝"x4⅞"x11⅝"	6"	195-215	3.9	3.9
7⅝"x4⅞"x11⅝"	8"	175-195	4.3	4.3
3⅝"x7⅝"x11⅝"	4"	195-215	3.9	3.9
5⅝"x7⅝"x11⅝"	6"	175-195	4.3	4.3
7⅝"x7⅝"x11⅝"	8"	155-175	4.8	4.8
9⅝"x7⅝"x11⅝"	10"	135-155	5.5	5.5
11⅝"x7⅝"x11⅝"	12"	115-135	6.4	6.4
3⅝"x3⅝"x15⅝"	4"	215-235	3.5	3.5
5⅝"x3⅝"x15⅝"	6"	195-215	3.9	3.9
7⅝"x3⅝"x15⅝"	8"	175-195	4.3	4.3
3⅝"x7⅝"x15⅝"	4"	190-210	4.0	4.0
5⅝"x7⅝"x15⅝"	6"	170-190	4.5	4.5
7⅝"x7⅝"x15⅝"	8"	150-170	5.0	5.0
9⅝"x7⅝"x15⅝"	10"	130-150	5.7	5.7
11⅝"x7⅝"x15⅝"	12"	110-130	6.7	6.7
7⅝"x7⅝"x15⅝"	8"	225-250**	3.4	3.4
11⅝"x7⅝"x15⅝"	12"	120-160**	5.7	5.7

Comparison of Concrete Masonry Sizes With Brick.—Allowing for the mortar joints in brickwork, the various sizes of concrete masonry units are equivalent to the following number of modular size brick, i.e., 2¼"x3⅝"x7⅝".

Size of Blocks	Brick Equivalent
4"x8"x16"	6
8"x8"x16"	12
12"x8"x16"	18

Cost of Concrete Masonry Units.—The prices quoted below are for index purposes only and are based on lightweight 8"x8"x16" block delivered to the job. As concrete masonry is widely

City	Price Each	City	Price Each
Baltimore	$0.20	Los Angeles	$0.28
Boston	.33	New Orleans	.30
Chicago	.27	New York	.32
Cincinnati	.25	Philadelphia	.25
Cleveland	.25	Pittsburgh	.26
Dallas	.28	San Francisco	.30
Denver	.30	St. Louis	.33
Detroit	.31	Seattle	.38
Kansas City	.26		

*If heavyweight concrete blocks are used, decrease quantities 10%, and increase labor hours accordingly. **Walls below grade.

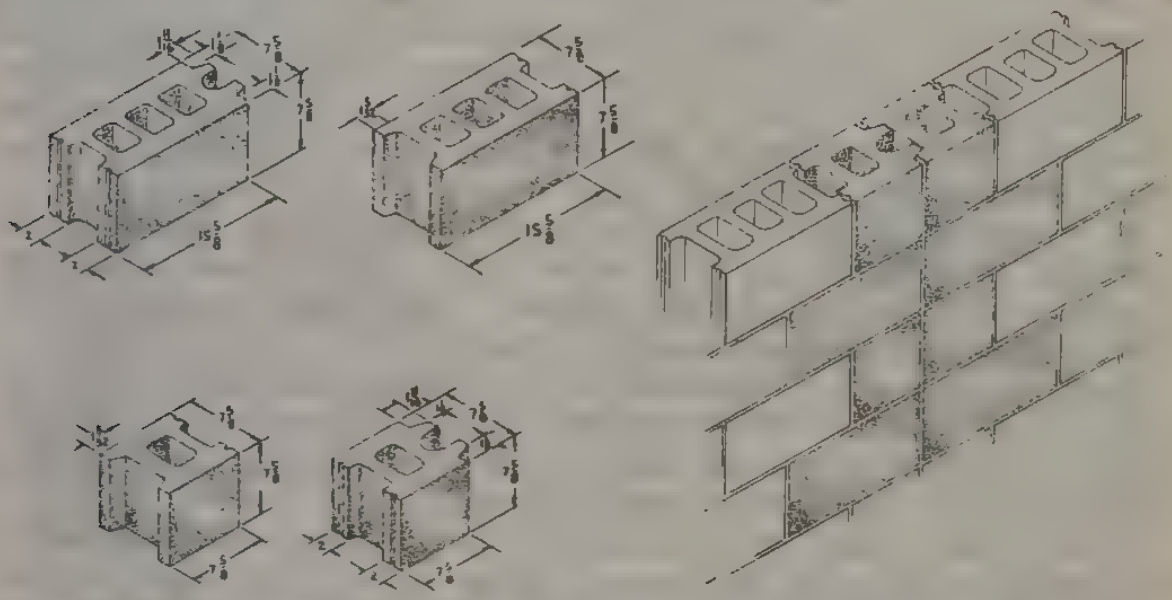
manufactured, the estimator is always close to the source of supply and costs on different size blocks are readily obtainable.

Precast reinforced concrete lintels can usually be obtained from concrete masonry manufacturers and the cost is slightly higher than for steel lintels.

Control Joints in Concrete Masonry

To control movements in concrete masonry walls from various kinds of stresses, increasing use is being made of control joints. Control joints are continuous vertical joints built into the walls in such locations and in such a manner as to permit slight wall movement without cracking the masonry.

The spacing and location of control joints will depend upon a number of factors, such as length of walls, architectural details and especially on the experience records as to the need for control joints in the particular locality where the structure is to be built. Control joints should be placed at junctions of bearing as well as nonbearing walls, at junctions of walls and columns or pilasters, in walls weakened by chases and open-



Method of Constructing Control Joints in Concrete Masonry Walls.

ings, etc. In long walls, joints are ordinarily spaced at approximately 20-ft. intervals, again depending upon local experience. As a rule, control joint locations are determined by the architect or engineer and are usually indicated on the drawings.

Control joints may be built with regular full and half-length stretcher block or full and half-length offset jamb block. With this type of joint construction, a non-corroding metal Z-tiebar, placed in every other horizontal joint across the control joint

will provide lateral support to wall sections on each side of the control joint.

In some localities, special control joint block are available. These block have tongue and groove ends which provide the required lateral support. These block are also made in full and half-length units.

To keep control joints as unnoticeable as possible, care must be taken to build them plumb and of the same thickness as the other mortar joints. If joint is to be exposed to weather or view, it should be raked out to a depth of at least ¾" and sealed with knife grade caulking compound.

The additional cost of building control joints, over and above the regular wall cost, will run 25 to 30 ct. per lin. ft. for material and 50 to 60 cts. per lin. ft. for labor.

Reinforced Concrete Masonry

Local conditions frequently demand special construction methods. For example, in earthquake regions it is necessary to provide more than ordinary stability for all types of structures. This is also true in areas where severe wind storms occur or where foundation soils are unstable. Moreover, in almost any locality there are structures which are subject to excessive vibrations, very heavy loads, extreme contraction or other stresses. Any of these examples of unusual stress conditions require special attention in designing and are often covered by local building codes.

In concrete masonry construction, additional strength is obtained by reinforcing the walls with steel reinforcing rods encased in poured grout or concrete. The walls may be reinforced horizontally, vertically or both.

Bond Beams.—To reinforce concrete masonry walls horizontally, bond beams are frequently used at each story height. Under extreme stress conditions, it may be necessary to use them in every second or third course.

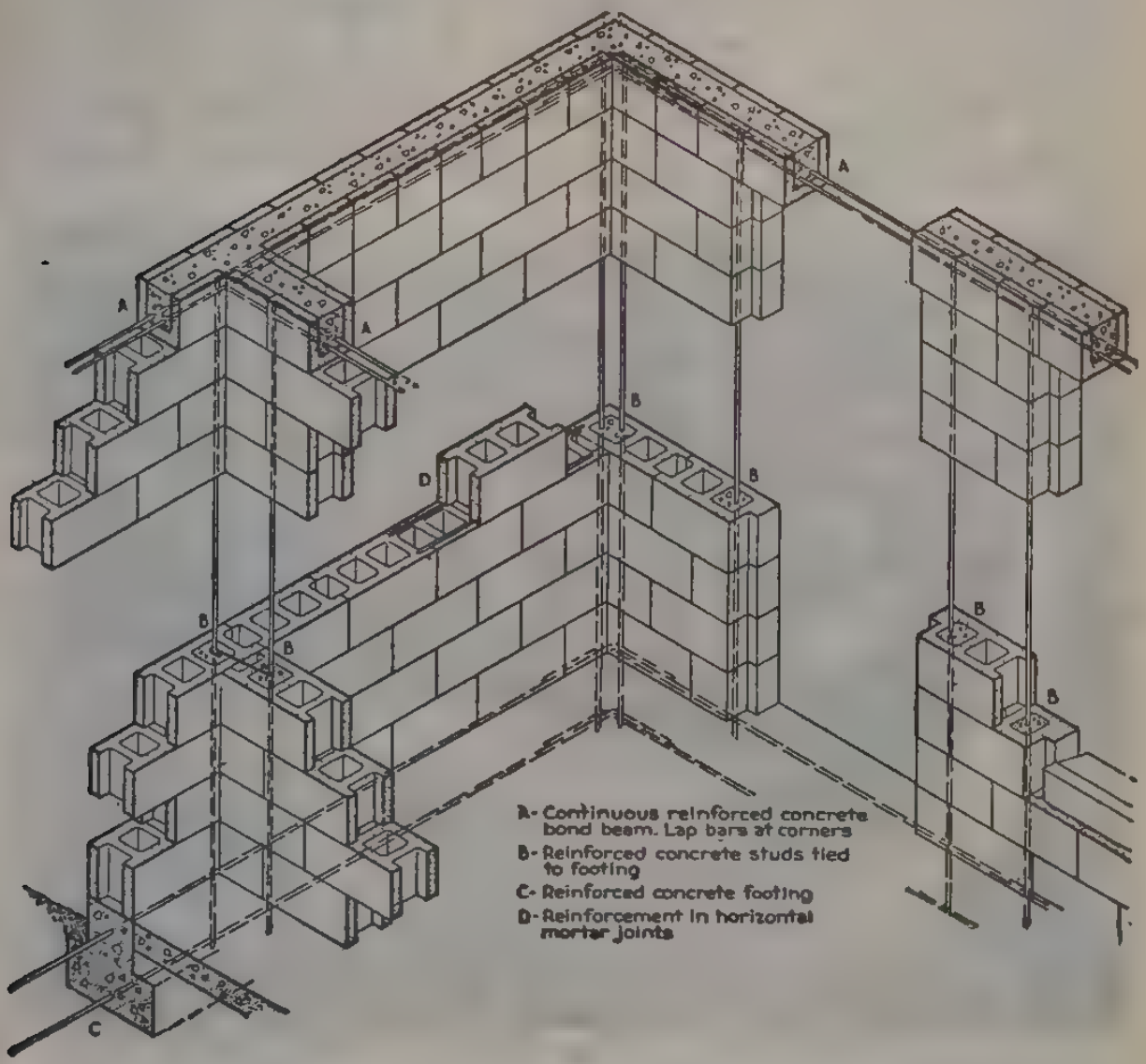
Bond beams may be constructed by forming and pouring a continuous ribbon of reinforced concrete at the course height required, but this method breaks up the continuity of the block pattern and may be objectionable.

In many localities, special bond beam blocks are available which are trough-shaped. When laid open-side-up, they form a continuous trough in which reinforcing steel and concrete encasement may be placed. Thus, the need for wood side forms is eliminated and the block pattern of the wall is preserved.

For estimating purposes, bond beams should be measured by the lin. ft. of beam for each size specified. The full cost for an average 8" x 8" bond beam should run 70 to 75 cts. per lin. ft.

for material and the same for labor where the cast-in-place method is used. Where bond beam blocks are used, the material cost should also run 70 to 75 cts. per lin. ft., but the labor cost should only run 35 to 45 cts. per lin. ft.

Bond beam blocks are also used to construct lintels over openings. Lintels may be pre-constructed on the ground and


A- Continuous reinforced concrete bond beam. Lap bars at corners
B- Reinforced concrete studs tied to footing
C- Reinforced concrete footing
D- Reinforcement in horizontal mortar joints

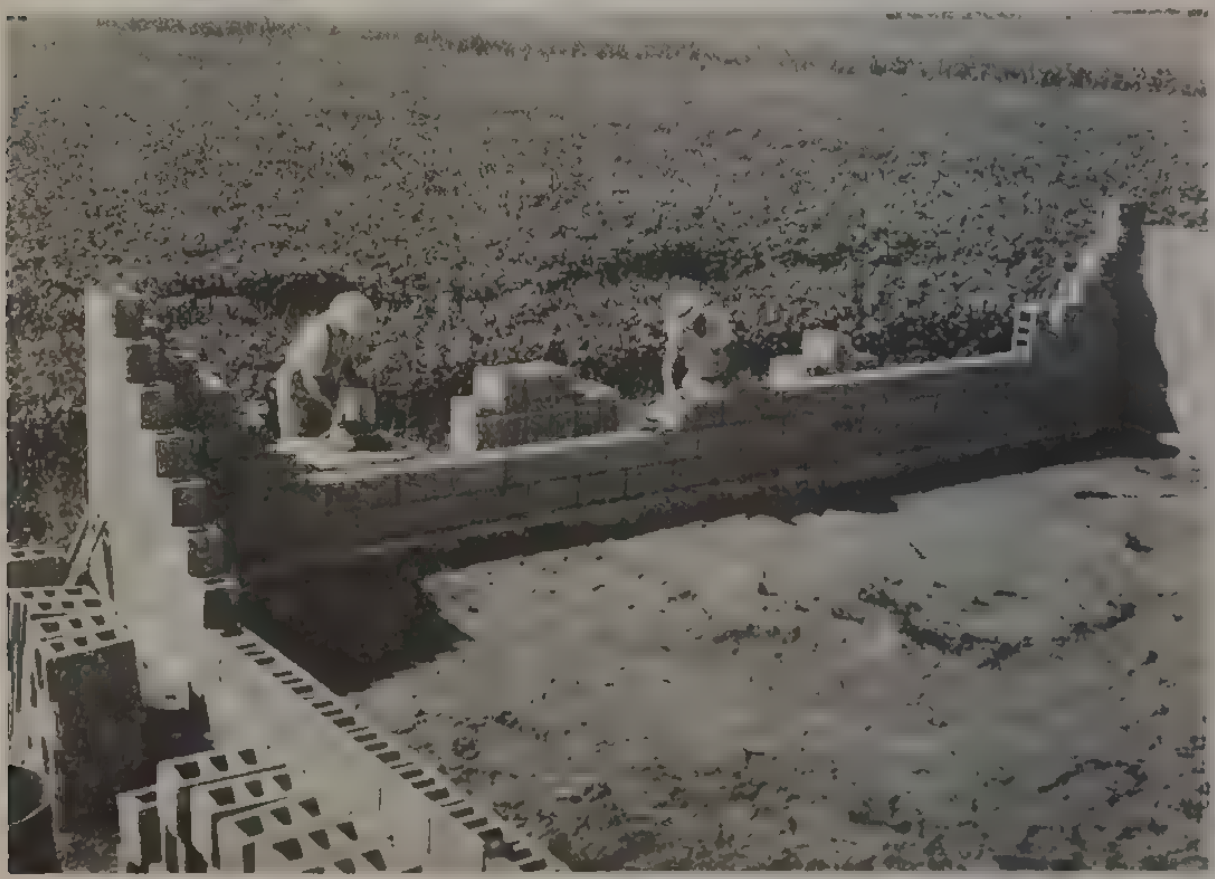
Method of Constructing and Reinforcing Concrete Masonry Walls.

set in place when they have attained sufficient strength or they may be built in place, using wood centers for support until mortar and concrete is strong enough to permit their removal.

Vertical Reinforcement in Concrete Masonry Walls.—Where vertical reinforcement is required in concrete masonry walls, it is usually located at building corners, jambs of wall openings and at regular intervals between wall openings. Size and spacing of reinforcement is usually covered by local building

codes. When used in conjunction with bond beams, vertical and horizontal steel should be tied together.

In placing vertical reinforcement, advantage is taken of the vertical alignment of hollow block cores which form wells into which the reinforcing bars are placed and grouted solid with poured mortar or concrete. At locations where vertical reinforcement is to occur, the bottom block should be left out for a cleanout hole when wall is laid up. Just prior to setting steel bars in place, the wells should be rodded clean of extruded mortar and debris removed from the cleanout. After cleaning, setting bars and inspection, cleanouts are closed with sideforms and the wells are grouted solid.



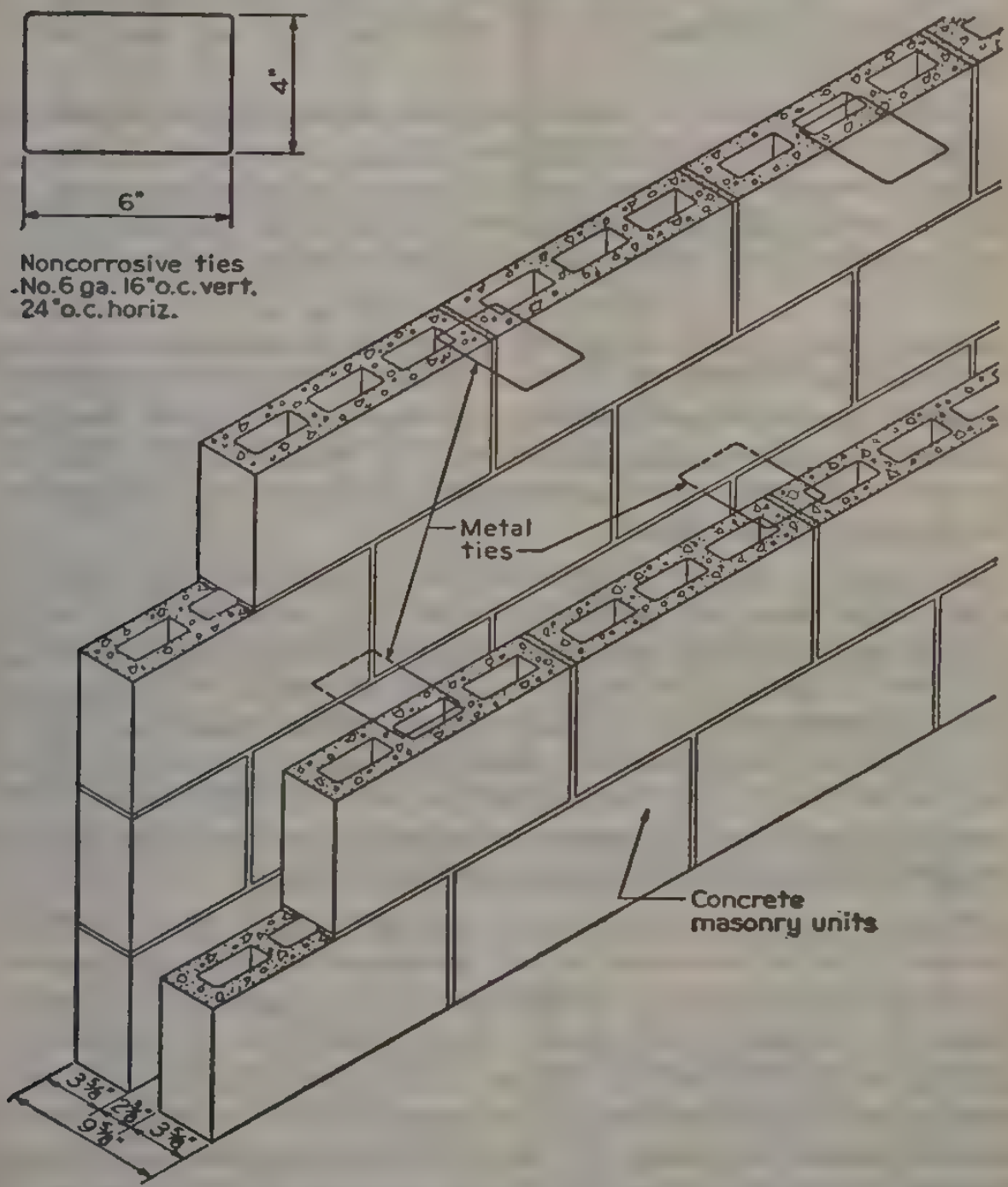
Laying Up a Concrete Masonry Wall Note Corners Are Built Up First.

For estimating purposes, vertical reinforcement should be measured by the lin. ft. of well or cores receiving same. The additional cost for reinforcing one well or set of cores with two ¾" diameter reinforcing rods and grouting same solid should run 35 to 40 cts. per lin. ft. for material and 40 to 50 cts. per lin. ft. for labor.

Concrete Masonry Cavity Walls

A cavity wall consists of two walls separated by a continuous air space and securely tied together with non-corroding metal ties

of adequate strength. For each 3 sq. ft. of wall surface a rectangular tie of No. 6 gage wire can be used. The ties are embedded in the horizontal joints of both walls. Additional ties are necessary at all openings, with ties spaced about 3 ft. apart around the perimeter and within 12 inches of the opening.



Method of Constructing Cavity Walls of Concrete Masonry.

Typical codes require that 10 inch cavity walls should not exceed 25 ft. in height. In residential construction the overall thickness of concrete masonry cavity walls are nominally 10″ or 12″.

Neither the inner nor outer walls should be less than 4 inches thick (nominal dimension) and the space between them should not be less than 2 inches nor more than 3 inches wide. Usually the outer wall is nominally 4 inches thick and the remaining wall thickness made up by the air space and the inner wall. For example, a modular concrete masonry cavity wall nominally 12 inches thick is composed of a 4″ outer wall, a 2″ air space and a 6″ inner wall.

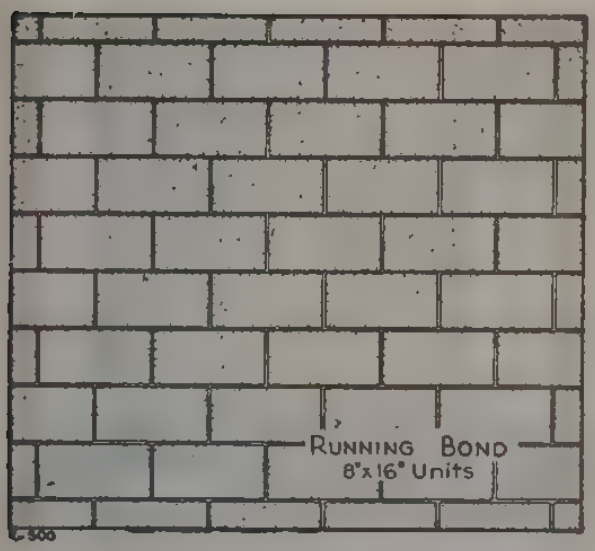
A simple method of preventing the accumulation of mortar droppings between walls and maintaining a clear cavity is to lay a 1″ x 2″ wood strip across a level of ties to catch the droppings. As the masonry reaches the next level for placing ties the strip is raised, cleaned and laid on the ties placed at this level.

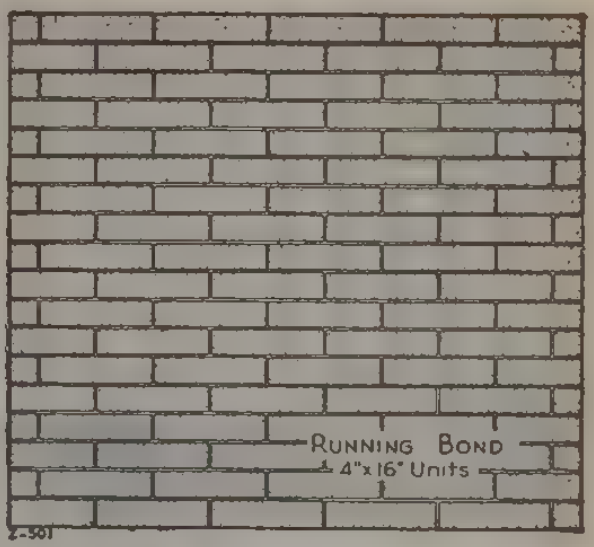
The practice of providing special flashing and weep holes in masonry cavity walls primarily presumes that water will enter the wall from the outside. If concrete masonry walls are properly designed and built with well-compacted mortar joints and are painted or stuccoed the walls should be weathertight. Thus, in the great majority of cases, there should be no need for special flashing and weep holes.

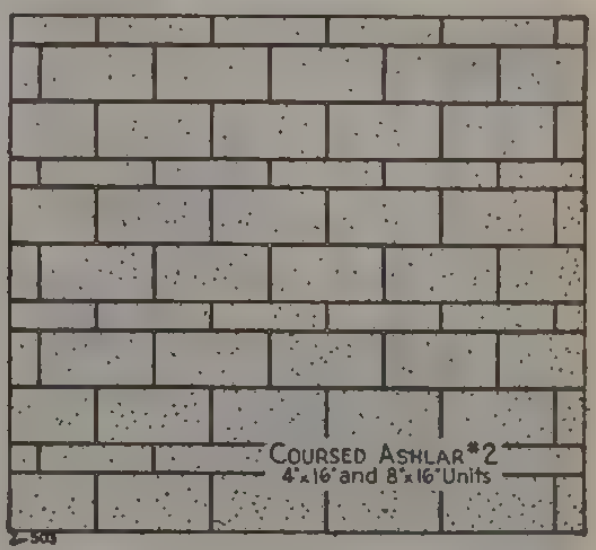
However, in limited areas subjected to severe driving rains, or where experience has shown that sufficient water collects in the wall to make flashing and weep holes necessary, this practice is followed: The heads of windows, doors and other wall openings, and the bottom course of masonry immediately above any solid belt course or foundation, are flashed so that any moisture entering the wall cavity will be directed toward the outside walls. Only rust-resisting metal or approved materials treated with asphalt or pitch preparations should be used for flashing.

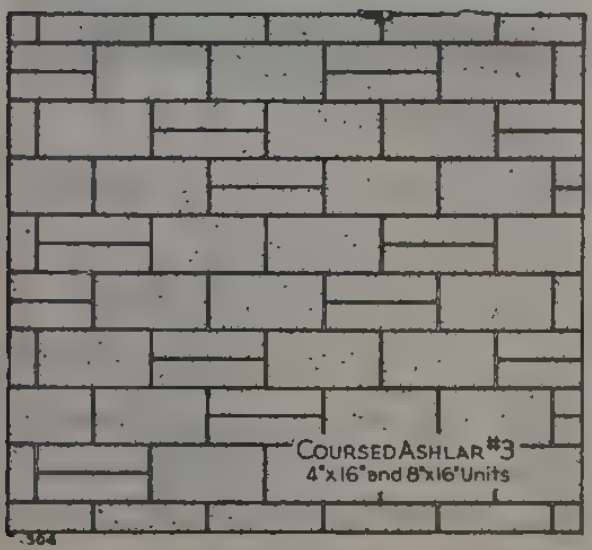
Weep holes are placed every 2 or 3 units apart in the vertical joints of the bottom course of the outside wall immediately above any solid belt course or foundation. In no case should the weep holes be located below grade. Weep holes can be formed by placing well-oiled rubber tubing in the mortar joint and then extracting it after mortar has become hard. The tubing should extend up into the cavity for several inches to provide a drainage channel through any mortar droppings that might have accumulated.

The labor cost of concrete masonry cavity walls varies the same as ordinary block walls according to the size of unit, pattern of

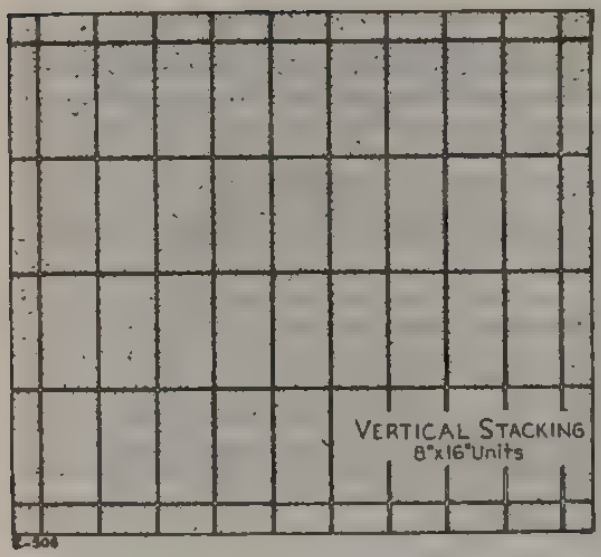


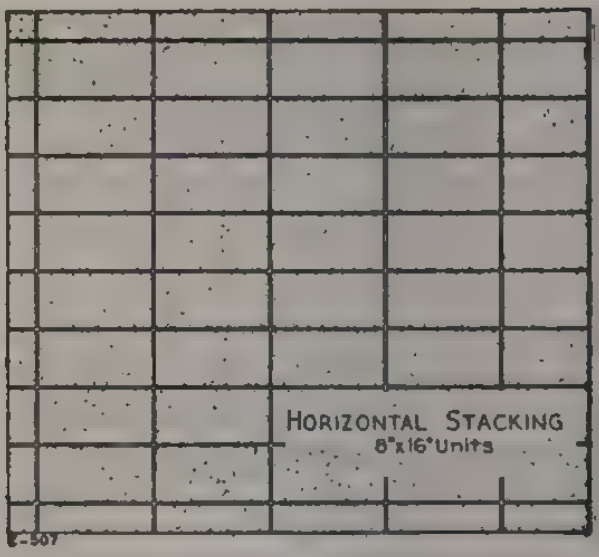


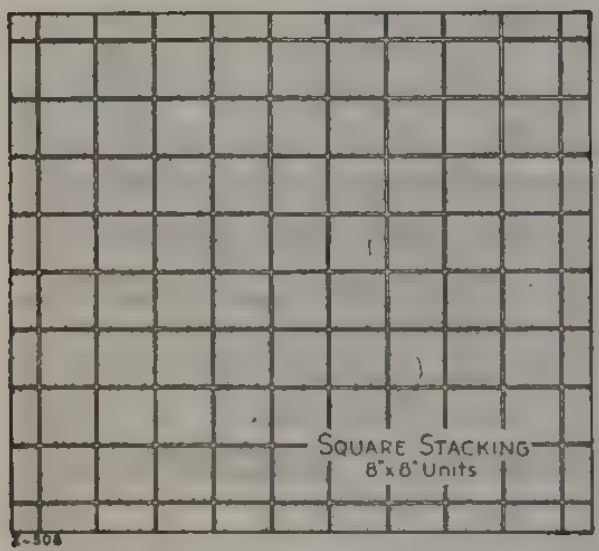


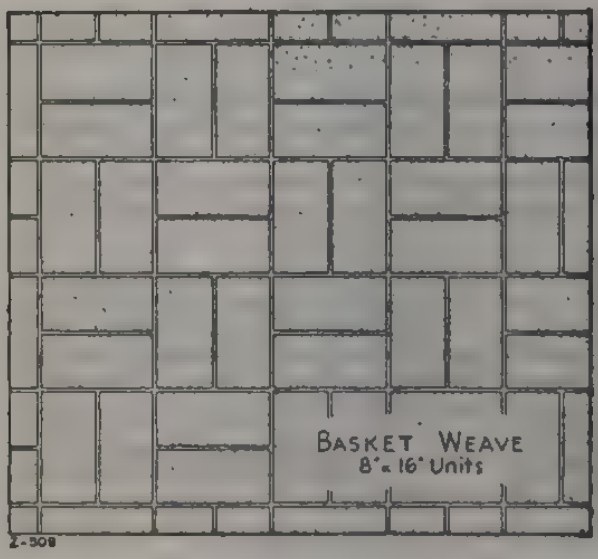


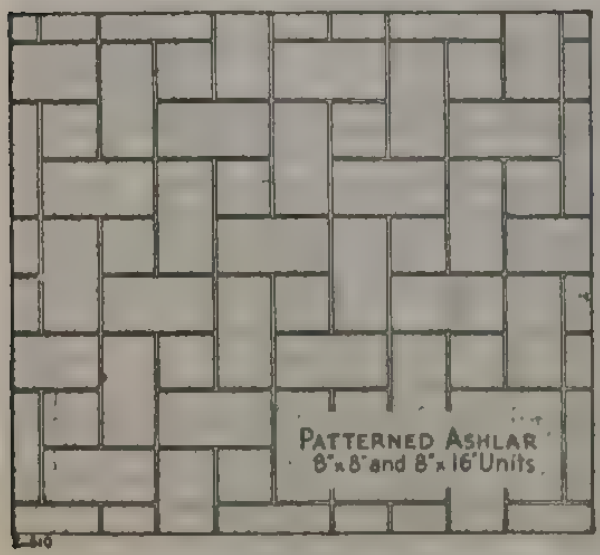
Methods of Laying Concrete Masonry Units for Exterior Facing

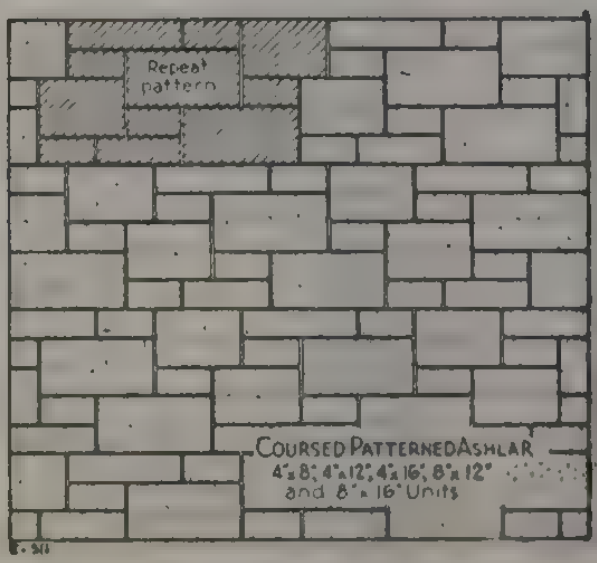










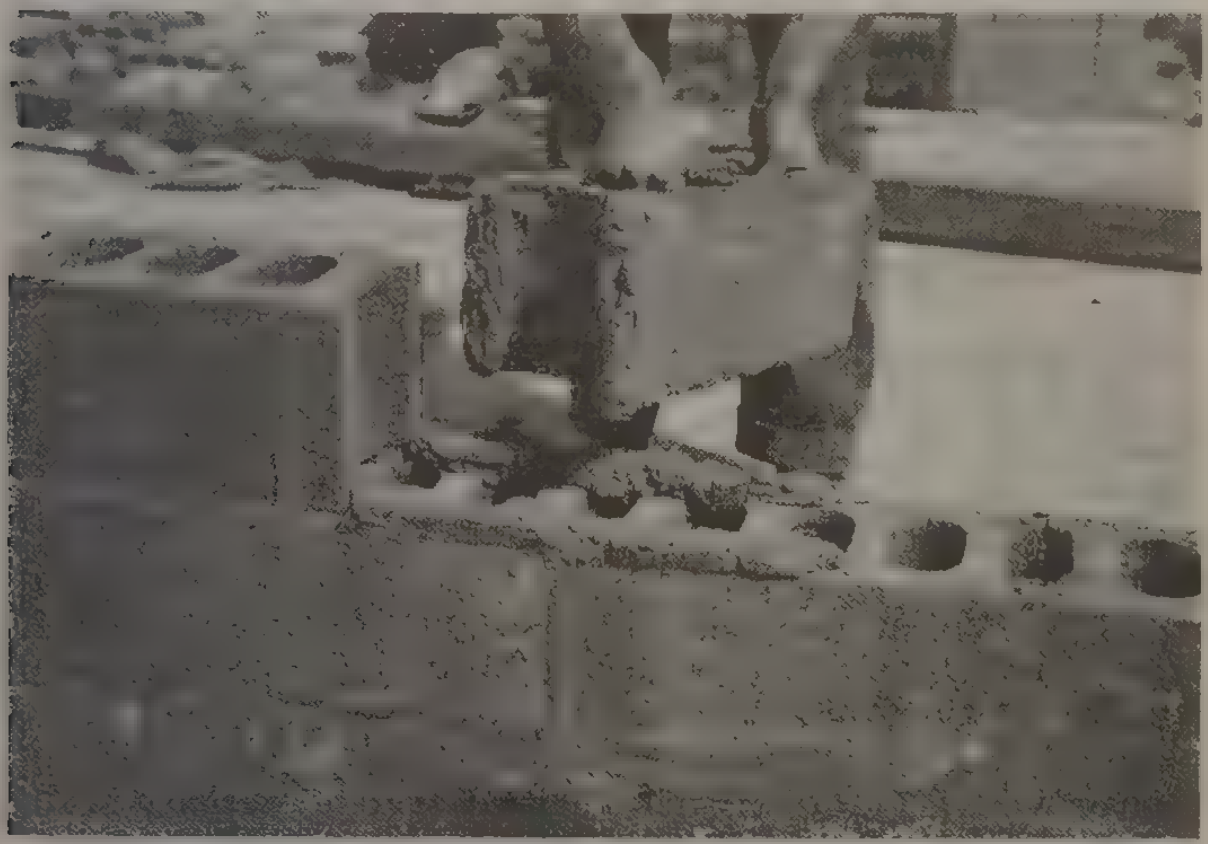


Methods of Laying Concrete Masonry Units for Exterior Facing

laying, nature of job, etc. A 10″ cavity wall consisting of two 4″ walls with a 2″ air space should cost about 15 percent more than the same two 4″ walls built separately. Similarly, a 12″ cavity wall consisting of one 4″ wall and one 6″ wall with a 2″ air space should cost approximately 15 percent more than the same 4″ and 6″ walls built separately.

Concrete Masonry Units Used for Exterior Facing

Concrete masonry walls are extensively used for exterior facing the same as face brick or stone. They may be laid up in any of the attractive designs shown in the accompanying illus-



Example of Horizontal and Vertical Face Shell Bedding

trations, ranging from straight ashlar to the many variations of random or broken ashlar.

Concrete masonry walls are frequently painted with white or light-colored cement base paints to give the desired architectural effect.

When used for exterior facing, the walls should be true and plumb and laid with full mortar coverage on vertical and horizontal face shells, (no furrowing permitted) with all vertical joints shoved tight. Mortar joints should be ⅜″ thick.

The mortar joints should be struck off flush with wall surface and when partially set shall be compressed and compacted with

a rounded or V-shaped tool. This provides a more waterproof mortar joint. An attractive treatment is obtained by emphasizing the horizontal joints and obscuring the vertical joints in concrete walls. This is done by tooling the horizontal joints and striking the vertical joints flush with the wall surface and then rubbing with carpet or burlap to remove the sheen from the troweled mortar surface

Lightweight concrete units should be used where obtainable as they provide better insulation than units made of ordinary concrete aggregates.

The labor costs given on the following pages are based on using lightweight units. If ordinary concrete units are used, add about 10 percent to labor costs given.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using 8"x16" Units, Laid in Regular Ashlar or Running Bond

	Walls 8" Thick Hours	Rate	Total	Rate	Total
115 8"x8"x16" units		$	$.....	$0.30	$ 34.50
6.5 cu. ft. 1:1:6 mortar		.....	.....	.603	3.92
Mason	5.75	.....	.....	7.10	40.82
Labor	4.25	.....	.....	5.00	21 25
Cost per 100 sq. ft.	10.00		$.....		$100.49
Cost per sq. ft.			.....		1.005

Add 10 percent to labor costs for 10" thick walls and 20 percent for 12" thick walls. Deduct 25 percent from labor costs for 4" veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using 4"x16" or Half Height Units Laid in Regular Ashlar or Running Bond

	Walls 8" Thick Hours	Rate	Total	Rate	Total
230 8"x4"x16" units		$.....	$	$0.18	$ 41.40
10 cu. ft. 1:1:6 mortar		.....	.....	.603	6.03
Mason	10	.....	.....	7.10	71.00
Labor	7	.....	.....	5.00	35.00
Cost per 100 sq. ft.	17		$.....		$153.43
Cost per sq. ft.			.....		1.534

Add 10 percent to labor costs for 10" thick walls and 20 percent for 12" thick walls. Deduct 25 percent from labor costs for 4" veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Coursed Ashlar No. 1, Using Alternate Courses of 8″x16″ and 4″x16″ Units

	Walls 8″ Thick Hours	Rate	Total	Rate	Total
77 pcs. 8″x8″x16″ units		$.....	$.....	$0.30	$ 23.10
77 pcs. 8″x4″x16″ units		.....	.....	0.18	13.86
7.3 cu. ft. 1:1:6 mortar		.....	.....	.603	4.40
Mason	7.9	.....	.....	7.10	56.09
Labor	5.7	.....	.....	5.00	28.50
Cost per 100 sq. ft.	13.6		$.....		$125.95
Cost per sq. ft.			.....		1.260

Add 10 percent to labor costs for 10″ thick walls and 20 percent for 12″ thick walls. Deduct 25 percent from labor costs for 4″ veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Coursed Ashlar No. 2, Consisting of Two Courses of 8″x16″ Units and One Course of 4″x16″ Units

	Walls 8″ Thick Hours	Rate	Total	Rate	Total
92 pcs. 8″x8″x16″ units		$.....	$.....	$0.30	$ 27.60
46 pcs. 8″x4″x16″ units		.....	.....	.18	8.28
6.8 cu. ft. 1:1:6 mortar		.....	.....	.603	4.10
Mason	7.3	.....	.....	7.10	51.83
Labor	5.3	.....	.....	5.00	26.50
Cost per 100 sq. ft.	12.6		$.....		$118.31
Cost per sq. ft.			.....		1.183

Add 10 percent to labor costs for 10″ thick walls and 20 percent for 12″ thick walls. Deduct 25 percent from labor costs for 4″ veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Coursed Ashlar No. 3, Consisting of 8″x16″ and 4″x16″ Units

	Walls 8″ Thick Hours	Rate	Total	Rate	Total
77 pcs. 8″x8″x16″ units		$.....	$.....	$0.30	$ 23.10
77 pcs. 8″x4″x16″ units		.....	.....	0.18	13.86
7.3 cu. ft. 1:1:6 mortar		.....	.....	.603	4.40
Mason	8.25	.....	.....	7.10	58.58
Labor	6.50	.....	.....	5.00	32.50
Cost per 100 sq. ft.	14.75		$.....		$132.44
Cost per sq. ft.			.....		1.324

Add 10 percent to labor costs for 10″ thick walls and 20 percent for 12″ thick walls. Deduct 25 percent from labor costs for 4″ veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Coursed Ashlar No. 4, Consisting of 8"x16" and 4"x16" Units

	Walls 8" Thick Hours	Rate	Total	Rate	Total
92 pcs. 8"x8"x16" units		$.....	$.....	$0.30	$ 27.60
46 pcs. 8"x4"x16" units		.....	.....	.18	8.28
6.8 cu. ft. 1:1:6 mortar		.....	.....	.603	4.10
Mason	7.9	.....	.....	7.10	56.09
Labor	5.7	.....	.....	5.00	28.50
Cost per 100 sq. ft.	13.6		$.....		$124.57
Cost per sq. ft.			.....		1.246

Add 10 percent to labor costs for 10" thick walls and 20 percent for 12" thick walls. Deduct 25 percent from labor costs for 4" veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Vertical Stacking of 8"x16" Units

	Walls 8" Thick Hours	Rate	Total	Rate	Total
115 pcs. 8"x8"x16" units		$.....	$.....	$0.30	$ 34.50
6.5 cu. ft. 1:1:6 mortar		.....	.....	.603	3.92
Mason	8.6	.....	.....	7.10	61.06
Labor	6.4	.....	.....	5.00	32.00
Cost per 100 sq. ft.	15.0		$.....		$131.48
Cost per sq. ft.			.....		1.315

Add 10 percent to labor costs for 10" thick walls and 20 percent for 12" thick walls. Deduct 25 percent from labor costs for 4" veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Horizontal Stacking of 8"x16" Units

	Walls 8" Thick Hours	Rate	Total	Rate	Total
115 pcs. 8"x8"x16" units		$.....	$.....	$0.30	$ 34.50
6.5 cu. ft. 1:1:6 mortar		.....	.....	.603	3.92
Mason	7.2	.....	.....	7.10	51.12
Labor	5.3	.....	.....	5.00	26.50
Cost per 100 sq. ft.	12.5		$.....		$116.04
Cost per sq. ft.			.....		1.16

Add 10 percent to labor costs for 10" thick walls and 20 percent for 12" thick walls. Deduct 25 percent from labor costs for 4" veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Square Stacking of 8″x8″ Units

	Walls 8″ Thick Hours	Rate	Total	Rate	Total
230 pcs. 8″x8″x8″ units...		$.....	$.....	$0.20	$ 46.00
7.6 cu. ft 1:1:6 mortar..		.....	.....	.603	4.58
Mason	12.50	.....	.....	7.10	88.75
Labor	8.75	.....	.....	5.00	43.75
Cost per 100 sq. ft.....	21.25		$. .		$183.08
Cost per sq. ft.....			.....		1.831

Add 10 percent to labor costs for 10″ thick walls and 20 percent for 12″ thick walls. Deduct 25 percent from labor costs for 4″ veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Basket Weave Design Consisting of 8″x16″ Units

	Walls 8″ Thick Hours	Rate	Total	Rate	Total
115 pcs. 8″x8″x16″ units...		$.....	$.....	$0.30	$ 34.50
6.5 cu. ft. 1:1:6 mortar..		.....	.....	.603	3.92
Mason	7.9	.....	.....	7.10	56.09
Labor	5.7	.....	.....	5.00	28.50
Cost per 100 sq. ft.	13.6	.....	$.....		$123.01
Cost per sq. ft.....			.....		1.230

Add 10 percent to labor costs for 10″ thick walls and 20 percent for 12″ thick walls. Deduct 25 percent from labor costs for 4″ veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Patterned Ashlar Consisting of 8″x16″ and 8″x8″ Units

	Walls 8″ Thick Hours	Rate	Total	Rate	Total
102 pcs. 8″x8″x16″ units...		$.....	$.....	$0.30	$ 30.60
26 pcs. 8″x8″x8″ units.....		.....	.....	.20	5.20
6.7 cu. ft. 1:1:6 mortar..		.....	.....	.603	4.04
Mason	8.4	.....	.....	7.10	59.64
Labor	6.2	.....	.....	5.00	31.00
Cost per 100 sq. ft.....	14.6		$.....		$130.48
Cost per sq. ft.....			.....		1.305

Add 10 percent to labor costs for 10″ thick walls and 20 percent for 12″ thick walls. Deduct 25 percent from labor costs for 4″ veneer facing.

Cost of 100 Sq. Ft. of Exterior Facing Concrete Masonry Walls Using Coursed Patterned Ashlar Consisting of 4"x8", 4"x12", 4"x16", 8"x12" and 8"x16" Units

	Walls 8" Thick				
	Hours	Rate	Total	Rate	Total
100 sq. ft. random ashlar		$.....	$.....	$0.41	$ 41.00
10 cu. ft. 1:1:6 mortar				.603	6.03
Mason	14			7.10	99.40
Labor	9			5.00	45.00
Cost per 100 sq. ft.	23		$.....		$191.43
Cost per sq. ft.					1.914

Add 10 percent to labor costs for 10" thick walls and 20 percent for 12" thick walls. Deduct 25 percent from labor costs for 4" veneer facing.

Insulating Fill for Concrete Masonry Walls.—For insulating masonry walls, a water-repellent vermiculite masonry fill is available. This is a free-flowing granular material, processed to provide a high degree of water-repellency. It is designed for the cores of masonry blocks and the voids of cavity walls. It does not bridge, and completely fills cores and cavities. Test installations show that the fill reduces heat loss up to 50 percent, and air-conditioning costs about 25 percent.

Vermiculite masonry fill is marketed in 4 cu. ft. bags. Approximate coverage is:

	Wall Area Sq. Ft.
2" cavity	24
2½" cavity	20
4½" cavity	11
6" block, 2 or 3 core	21
8" block, 2 or 3 core	14½
12" block, 2 or 3 core	8

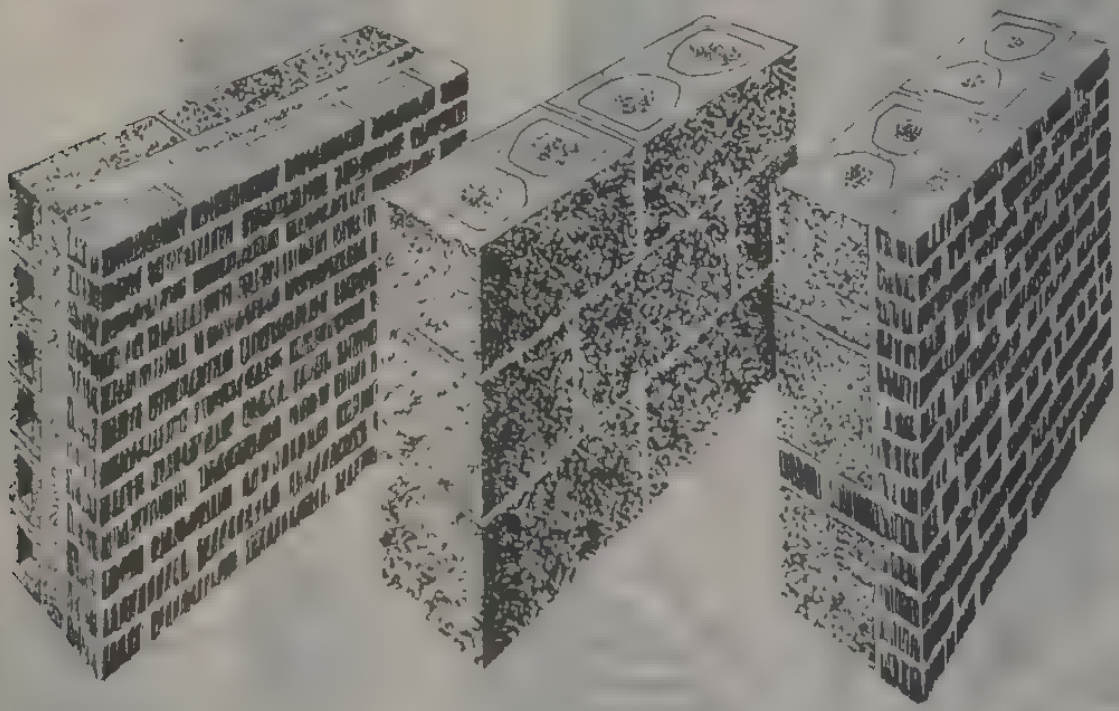
Cost of material for insulating an 8"x8"x16" concrete block is about 15 cts. per sq. ft. For a cavity wall, 5 cts. per bd. ft. Installation cost is about 1 ct. per sq. ft.

Masonry fill is also effective sound-deadening in masonry block partitions between occupancies. Silicone treated perlite loose fill insulation insulates masonry walls to give greater comfort at lower cost. Silicone treated perlite pours readily into the cores of concrete block or cavity type masonry walls. Tests prove it reduces winter and summer heat transfer 50 percent or more. Silicone treatment of perlite provides lasting water repellency, prevents moisture penetration, and assures constant insulating efficiency in the most severe weather, including wind driven rain.

Insulating the Cores of Masonry Units with Water-repellent Vermiculite Masonry Fill.

Performance is rated excellent in accordance with test procedures developed by the National Bureau of Standards.

Silicone treated perlite loose fill insulation is manufactured nationally and marketed in 4 cu. ft. bags. Coverage is approximately the same as shown for vermiculite. Installed costs will also be competitive with other loose fill materials.



Silicone Treated Perlite Fill in Masonry Walls

Special Facing Blocks

In many areas, special block are available for the purpose of creating special facing effects. These block range from ordinary cement block, scored across the face to give the appearance of additional joints, to block made or faced with special aggregates which produce various textures and colors.

Scored Block.—The simplest departure from ordinary block facing is obtained by scoring regular block one or more times across the face to give the illusion of shallower units and more joints. Most block manufacturers can furnish scored units for about 5 cts. per score in addition to the regular block price.

Labor costs for laying up this type of facing is about the same as for a regular running bond facing except when scored grooves are pointed with mortar and tooled to match the actual joints.

Split-Block.—Split-block afford another variation in wall finish. Split-block are made by splitting a hardened concrete

unit lengthwise. The units are laid in the wall with the fractured face exposed. Many interesting variations can be obtained by introducing mineral colors and by using aggregates of different gradings and colors in the concrete mixture.

Split-block can be laid in simple running bond or in any of the other patterns used in concrete masonry construction. The fractured faces of the units produce a wall of rugged appearance.

Prices for 4" thick split-block veneer units run from $1.10 to $1.35 per sq. ft. of wall depending upon the size of units and pattern used.

Labor costs will be about the same as given on previous pages for the various patterns illustrated.

Slump Block.—For a weathered stone effect, slump block are used. When manufacturing slump block, a special consistency mixture is used so that unit will sag or "slump" when released from the molds before complete "setting." This method produces many artistic irregularities with variations in height, texture, etc. Many are integrally colored in varying shades. Standard heights vary $1\frac{5}{8}$" to $3\frac{5}{8}$" and units are usually laid in a random ashlar pattern, although coursed patterns may be used if desired.

The cost of slump block varies with the locality and prices should be obtained locally when figuring this work. Prices range from 80 cts. to $1.00 per sq. ft. of wall facing.

Mortar requirements for slump block facing are high due to the irregularities of the material and approximate those of random ashlar stone work. As an average, it will require about 10 cu. ft. of mortar per 100 sq. ft. of 4" veneer facing.

When laying slump block in a random ashlar pattern, a mason and a helper should lay 45 to 55 sq. ft. of 4" veneer facing per 8-hr. day.

Cost of 100 Sq. Ft. of 4" Slump Block Veneer, Laid in Random Ashlar Pattern

	Hours	Rate	Total	Rate	Total
100 sq. ft. slump block...		$.....	$.....	$1.00	$100.00
10 cu. ft. 1:1:6 mortar...		.....	.....	.603	6.03
Mason	16	.....	.....	7.10	113.60
Labor	16	.....	.....	5.00	80.00
Cost per 100 sq. ft.	32		$.....		$299.63
Cost per sq. ft.					2.996

CONCRETE STORAGE BINS AND SILOS

Concrete storage bins and silos are used for storing grain, coal, sand, gravel, etc., in addition to those used for the processing and preserving of forages for feed on the farm.

Silos are constructed of numerous types of materials such as concrete stave, cast-in-place concrete, concrete block, glazed tile, wood, and steel. The cost of storage silos varies with the storage capacity, the type of structure and the kind of materials to be stored.

Practically all silos are round or circular as this shape gives more capacity for the least amount of construction cost, and the stored material packs better.

Farm silos are built for storing corn, sorghum, hay crops and miscellaneous forages. Research studies reveal that lateral pressures increase with the moisture content of the silage and the size of the silo. All silages exert approximately equal lateral pressures when of the same moisture content. Therefore, the reinforcing requirements are identical. However, hay crop silages are usually stored at excessive moisture content and more reinforcing is recommended.

The table on page 594 is reproduced from American Concrete Institute, Standard 714, "Recommended Practice for the Construction of Concrete Farm Silos." The hoop spacing is for concrete stave silos designed for silage with a moisture content not exceeding 75 percent.

Excavating and Concrete Foundations for Silos

Footings should be ample to carry the weight of the silo without settlement or tipping. The width and depth, therefore, are varied according to the height of the silo and the load-carrying capacity of the soil. Recommended footing sizes are given in the accompanying table. These take into consideration the bearing power of the different soils as well as the weights of silos of different heights, including the weights of the concrete chutes, roofs, and the weight of the silage carried by the walls.

The depth of the foundation wall below ground level will vary according to the location of the silo. The footings should extend below frost penetration and to firm soil. The bottom of the trench for the footing should be flat and even in width to assure uniform distribution of the load to the soil. Forms will not be

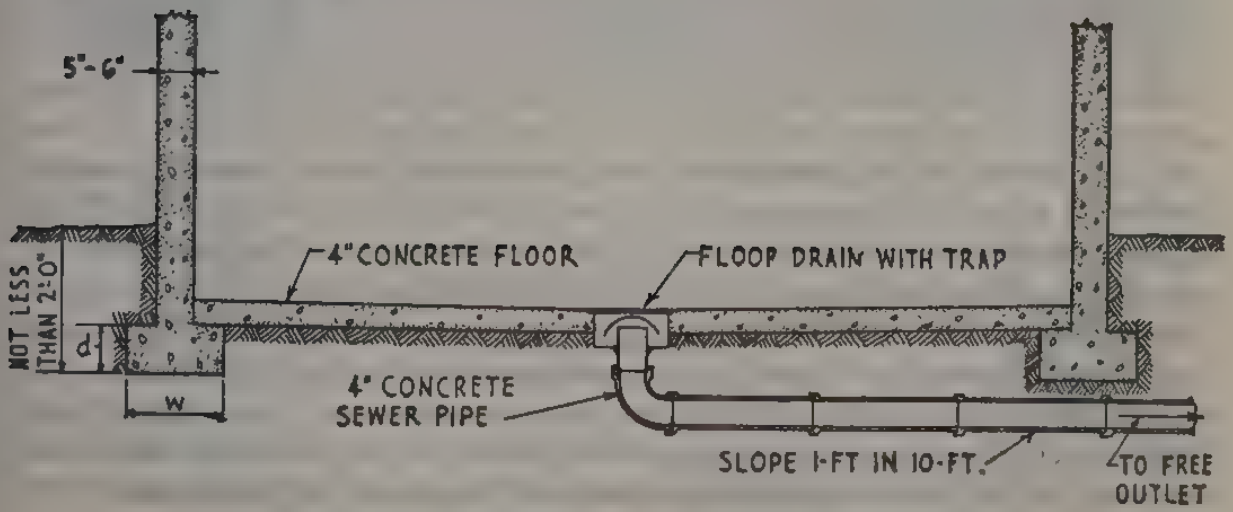
required for construction of the footings if care is taken to excavate the trench so that the walls stand vertically. Wall forms are used from the footing up.

Dimensions of Annular Footings for Silos with Walls 6 Inches Thick*

Height of Silo ft.	TYPE OF SOIL**					
	Sand and Gravel (Type 1)		Firm clay, wet sand or clay and sand mixture (Type 2)		Soft Clay (Type 3)	
	Width Inches	Depth Inches	Width Inches	Depth Inches	Width Inches	Depth Inches
20	12	8	12	8	17	8
25	12	8	12	8	24	8
30	12	8	16	8	32	11
35	12	8	21	10	Silos Higher Than 30 ft. Not Recommended on Type 3 Soil	
40	13	9	26	13		
45	16	11	32	15		
50	19	13	Silos Higher Than 45 ft. Not Recommended on Type 2 Soil			
55	23	16				

* A.C.I.—714.

** Soil Pressures in p.s.f. (Type 1) 8,000, (Type 2) 4,000, (Type 3) 2,000.



Concrete Foundation and Floor for Cast-in-Place Concrete Silos.

Cubic Feet of Excavation or Concrete Footing Required For Silo Foundations of Various Sizes Per Inch of Depth or Thickness

Footing Width Inches	Dia. Ft. 10 Cir. Ft. 32	12 38	14 44	16 50	18 57	20 63	22 69	24 76
12	2.67	3.17	3.67	4.17	4.75	5.25	5.75	6.33
13	2.89	3.43	3.97	4.51	5.14	5.69	6.23	6.86
16	3.55	4.22	4.88	5.55	6.33	7.00	7.67	8.44
17	3.77	4.48	5.19	5.90	6.72	7.44	8.14	8.97
19	4.21	5.01	5.80	6.59	7.51	8.31	9.10	10.03
21	4.66	5.53	6.40	7.28	8.30	9.19	10.06	11.08
23	5.10	6.06	7.01	7.97	9.10	10.06	11.02	12.15
24	5.33	6.33	7.33	8.33	9.50	10.50	11.50	12.67
26	5.55	6.86	7.94	9.03	10.29	11.37	12.45	13.72
27	5.77	7.12	8.25	9.37	10.68	11.81	12.95	14.25
32	7.10	8.44	9.77	11.10	12.65	14.00	15.33	16.90

Diameter and Circumference of Standard Size Silos

Diam. Silo in Ft.	Circum. Silo in Ft.	Nominal Circum. in Ft.	Diam. Silo in Ft.	Circum. Silo in Ft.	Nominal Circum. in Ft.
10	31.42	32	18	56.55	57
12	37.70	38	20	62.83	63
14	44.00	44	22	69.10	69
16	50.27	50	24	75.41	76

To obtain number of cubic feet or cubic yards of excavation or footings required for any job, proceed as follows: Find number of cubic feet of concrete required for a silo 16 feet in diameter, requiring a footing 19" wide and 13" thick. Refer to above table: a 16-ft. diameter silo requiring a footing 19" wide, requires 6.59 cu. ft. of concrete per inch in thickness. Multiply 6.59 by 13" (thickness of footing) and the result is 85.67 cu. ft. of concrete for the footing.

Silo Wall Forms.—The use of commercial steel forms is recommended for the construction of cast-in-place silos. Such forms are quickly set and removed and result in true, smooth walls. Several types of commercial steel forms are available. They differ from each other mainly in the size of the sections or panels and in the manner they are fitted together. In all types, the sections are curved and joined together snugly with clamps to form a complete circle or course. One course of forms is referred to as a lift. Each course or circle is 2 or more feet high, according to the forms used. From 6 to 8 feet of wall can be built in a day, depending upon the size of the crew and the outdoor temperature. In summer weather, forms can usually be

removed in 24 hours. In building 6 or 8-ft. of wall per day, three or four complete courses of forms, using 2-ft. high sections, will be required. The usual practice is to set and fill one lift at a time. Where three or more courses of forms are in use it is the usual practice to remove the lower course and set it on top. This procedure is continued until the required height of wall is built. Form faces are cleaned and re-oiled for each re-setting.

A plumb wall is assured when using commercial forms provided the first course is carefully leveled. Each manufacturer usually furnishes instructions covering the use of his forms. These companies also make forms for casting chutes and roofs

Placing Metal Forms for Cast-in-Place Concrete Silos.

and can furnish erection derricks, hoists and other construction accessories.

Constructing the Walls.—Walls of well-built cast-in-place silos are smooth, plumb, air and watertight. The walls are 4 to 6-in. thick. A 5 to 6-in. thickness is recommended for large silos.

Concrete for durable silo walls should be of high quality, using clean sharp sand and gravel. Sand should be from very fine up to particles which pass a No. 4 screen (4 openings per lin. in.). Gravel should be clean, hard and range in size from ¼" up to 1½".

A workable concrete mix is one which is "mushy" but not

"soupy." It should be somewhat sticky when worked with a shove or trowel and should be stiff enough to require some spading in th forms. For machine mixing allow about 2 minutes mixing after al materials are in the mixer. Concrete for footing should be mixe in approximately the proportions of 1 bag air entrained portlan cement; 2¾ cu. ft. sand and 4 cu. ft. gravel. Use about 5 gals. wate per bag of cement. Concrete for walls, floor, chute and roof shoul be mixed in the proportions of 1 bag of air entrained portlan cement; 2¼ cu. ft. sand and 3 cu. ft. gravel. Use about 5 gals. wate per bag of cement.

Material Required for One Cu. Yd. 1:2¾:4 Concrete

	Rate	Total	Rate	Total
5 bags portland cement	$.....	$.....	$1.80	$ 9.00
14 cu. ft. sand.....	.....	.....	.15	2.10
20 cu. ft. gravel.....	.....	.....	.15	3.00
Cost per cu. yd.....		$.....		$14.10

Material Required for One Cu. Yd. 1:2¼:3 Concrete

	Rate	Total	Rate	Total
6.25 bags portland cement	$.....	$.....	$1.80	$11.25
14 cu. ft. sand.....	.....	.....	.15	2.10
19 cu. ft. gravel.....	.....	.....	.15	2.85
Cost per cu. yd.....		$.....		$16.20

Approximate Quantities of Concrete Materials Required Fo Cast-in-Place Concrete Silos of Various Diameters*

Inside diameter, ft.	For silo 30 ft. high			For each additional 5 ft.		
	Cement, bags	Sand, cu.yd.	Gravel, cu.yd.	Cement, bags	Sand, cu.yd.	Gravel cu.yd.
14	174	15	20	26	2¼	3
16	200	17	23	30	2½	3½
18	225	19	26	34	2¾	3¾
20	252	21	29	37	3	4¼
22	287	24	32	43	3½	5
24	317	27	37	48	4	5½

*Includes 6" walls, concrete chute, dome roof and 4" floor. Materi for footings must be added.

Total Weight of Horizontal and Vertical Bars Required For Cast-in-Place Concrete Silos

Height of silo, ft.	Diameter of silo					
	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
20	547	652	.....	.....	.....	.....
24	675	796	968	1,263	.....	.....
28	787	935	1,174	1,492	.....	.....
32	910	1,047	1,381	1,721	2,014	2,609
36	1,034	1,213	1,587	2,017	2,351	3,112
40	.....	1,400	1,816	2,339	2,836	3,649
44	.....	.....	2,044	2,702	3,291	4,317
48	.....	.....	2,351	3,066	3,780	4,986
52	.....	.....	.....	3,430	4,386	5,654

No allowance made for lapping of bars. Add approximately 10 percent when three lengths of bars are used per circle.

Number and Length of Horizontal Reinforcing Bars Required For Cast-in-Place Concrete Silos with Continuous Doorway

Height of silo, ft.	Diameter of silo					
	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Length of bars *					
	31 ft. 10 in.	38 ft. 0 in.	44 ft. 4 in.	50 ft. 6 in.	56 ft. 10 in.	63 ft. 4 in.
	Number of bars required					
20	14	17	.....	16	.....	.....
24	17	21	14	20	.....	.....
28	20	25	18	24	.....	.....
32	24	29	22	28	20	26
36	28	33	26	34	24	32
40	.....	39	30	40	30	38
44	.....	.....	34	48	36	46
48	.....	.....	38	56	42	54
52	.....	.....	.....	64	50	62
	No. 3 Bars		No. 4 Bars		No. 5 Bars	

* Bar lengths do not allow for laps. Add approximately 10% when three lengths of bar are used per circle.

Basis for Estimating Labor for Cast-in-Place Concrete Silos.—The following estimating data is applicable to and based on

Number and Length of Vertical Reinforcing Bars Required For Cast-in-Place Concrete Silos

Height of silo, ft.	Length of bars	Diameter of silo							
		10′	12′	14′	16′	18′	20′	22′	24′
		Number of bars required							
20	20 ft. 0 in.	22	26	.....	.....	.....	.....	....	....
24	13 ft. 0 in.	44	52	60	68	.....	.....	....	....
28	15 ft. 0 in.	44	52	60	68	.....	.....	....	....
32	17 ft. 0 in.	44	52	60	68	76	86	92	102
36	19 ft. 0 in.	44	52	60	68	76	86	92	102
40	14 ft. 8 in.	.....	78	90	102	114	129	138	153
44	16 ft. 0 in.	.....	78	90	102	114	129	138	153
48	17 ft. 4 in.	.....	.....	90	102	114	129	138	153
52	18 ft. 8 in.	.....	.....	90	102	114	129	138	153
60	16 ft. 6 in.	.....	....	120	136	152	168	184	204

All bars are No. 3, spaced 18" apart. Bars are lapped 24 in. at splices.

circular type cast-in-place concrete silos.

The labor excavating and placing concrete footings for silo should be estimated separately, as they will vary with the dept of excavation and size of silo.

After the footings are in place, an experienced crew of thre men should build 8 feet of 10′-0", 12′-0" or 14′-0" diameter sil per 8-hr. day, including the labor on feed room. It will als require about a day to place the roof, and after the concrete i placed, a day will be required to tear down and remove th forms and equipment.

Labor Required to Construct Cast-in-Place Concrete Silos

Labor Required to Construct Each 8′-0" of Wall Height

Diam. of Silo	Thickness of Wall	Number of Men in Crew	Number Hours for Crew	Labor Hours for Each 8′-0" Height
10′-0"	5"-6"	3	8	24
12′-0"	5"-6"	3	8	24
14′-0"	5"-6"	3	8	24
Roof	.....	3	8	24
16′-0"	5"-6"	4	8	32
18′ 0"	5"-6"	4	8	32
20′-0"	5"-6"	4	8	32
22′-0"*	5"-6"	4	8	32
24′-0"*	5"-6"	4	8	32
Roof	.....	4	8	32

*Labor required to construct each 6 ft. of wall height.

A set of metal forms usually includes 4 sets of forms 2'-0" high.

Reinforcing steel may be either rods or mesh but many silo builders prefer mesh reinforcing as it may be placed at lower cost than rods.

To the above, add labor cost excavating for footings, also labor placing concrete footings.

To the above, add time for 1 day for crew bringing tools and equipment to job and setting up; also 1 day tearing down and removing equipment at completion.

Silo Walls Using Slip Forms.—For casting monolithic concrete structures of great height the method of slip forms is often used and this type of form is particularly adaptable to the construction of silos and storage bins. Despite the fact that the sliding forms must be built with more precision and of heavier material than fixed forms, slip forms have proven to be more economical in the long run for high structures. Naturally the higher the construction the less the cost per square foot of wall.

The forms are prefabricated of wood or metal and are usually raised by using screw jacks or a hydraulic jacking system. The yokes which are usually made of wood and tied together with bolts are suspended with a screw or jack arrangement on a steel jackrod. The raising is done by a crew of men, each man operating from 1 to 5 jacks depending on the size of the job. This operation must be done on a shift basis, continuing day and night until the structure is completed to prevent the forms from adhering to the concrete.

Concrete Stave Silos

Footings for concrete stave silos can be made smaller than those for cast-in-place silos, because staves are only 2½" thick. American Concrete Institute Bulletin 714 gives the following information for footings for concrete stave silos.

Concrete Staves.—Concrete stave silos are built of cast concrete staves usually 10" wide, 30" long and 2½" thick. Every other stave in the bottom circle is 24" high with a 6" stave at the top of the corresponding column.

The number of staves required may be computed by figuring the number of staves for each circle, with the height of the structure governing the number of circles required.

Dimensions of Annular Footings for Silos with Walls 2½ Inches Thick

Height of Silo ft.	TYPE OF SOIL					
	Sand and Gravel (Type 1)		Firm clay, wet sand or clay and sand mixture (Type 2)		Soft Clay (Type 3)	
	Width Inches	Depth Inches	Width Inches	Depth Inches	Width Inches	Depth Inches
20	12	8	12	8	12	8
25	12	8	12	8	18	8
30	12	8	12	8	24	8
35	12	8	16	8	32	11
40	12	8	21	10		
45	13	9	26	13	Silos Higher Than 35 ft. Not Recommended on Type 3 Soi	
50	16	11	32	15		
55	19	13				
60	23	16	Silos Higher Than 50 ft Not Recommended on Type 2 Soil			

Labor Setting Staves.—The setting of 1,000 10"x30" staves may be considered a fair day's work under average conditions for a 4-man crew, consisting of 2 men on the ground, 1 man setting staves, and a foreman to followup, leveling staves and inspecting the tension of hoops. This includes the raising of the necessary scaffolding, placing and tightening hoops, etc.

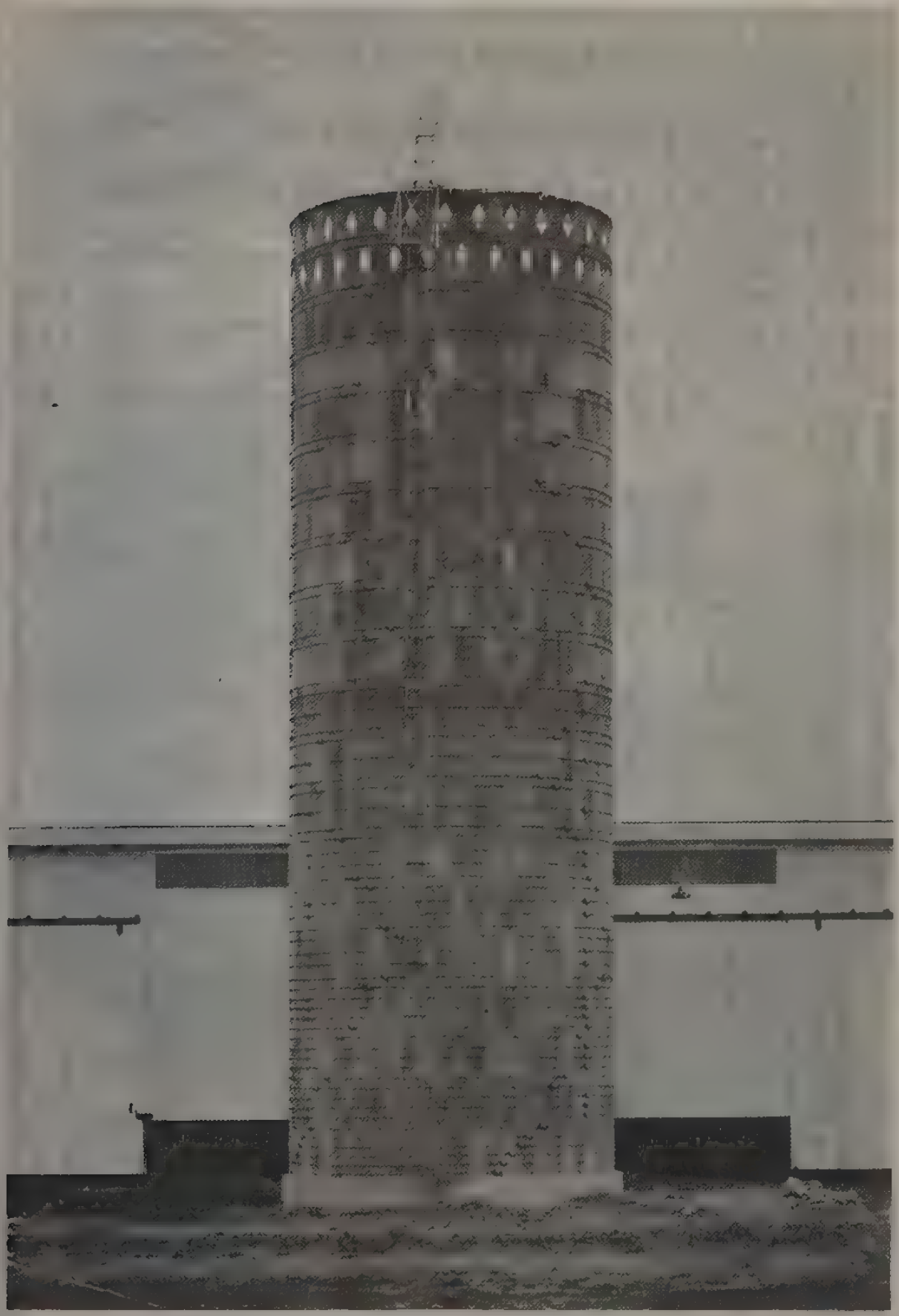
Number of Staves Required Per Circle for Concrete Stave Silo

The number of staves required for one complete circle of various size silos. Use last (*) column where door frames are included.

Diameter of Silo	Outside Diameter of Silo	Number of Staves per Circle	Number of Staves per Circle*
10′-0″	10′-4″	38	35
12′-0″	12′-6″	46	43
14′-0″	14′-4″	53	50
16′-0″	16′-5″	61	58
18′-0″	18′-6¾″	69	66
20′-0″	20′-8″	77	74

Hoops for Concrete Stave Silos.—It will be necessary to place steel rods or "hoops" around the concrete stave silo to reinforce the staves. The hoops spacing for either grass or corn silage of moisture content not over 75 percent should not exceed that given in the table of "Hoop Spacing for Concrete Stave Silos."

Lugs (connections for hoops of round cross-section) should be



Concrete Stave Silo

Hoop Spacing for Concrete Stave Silos *

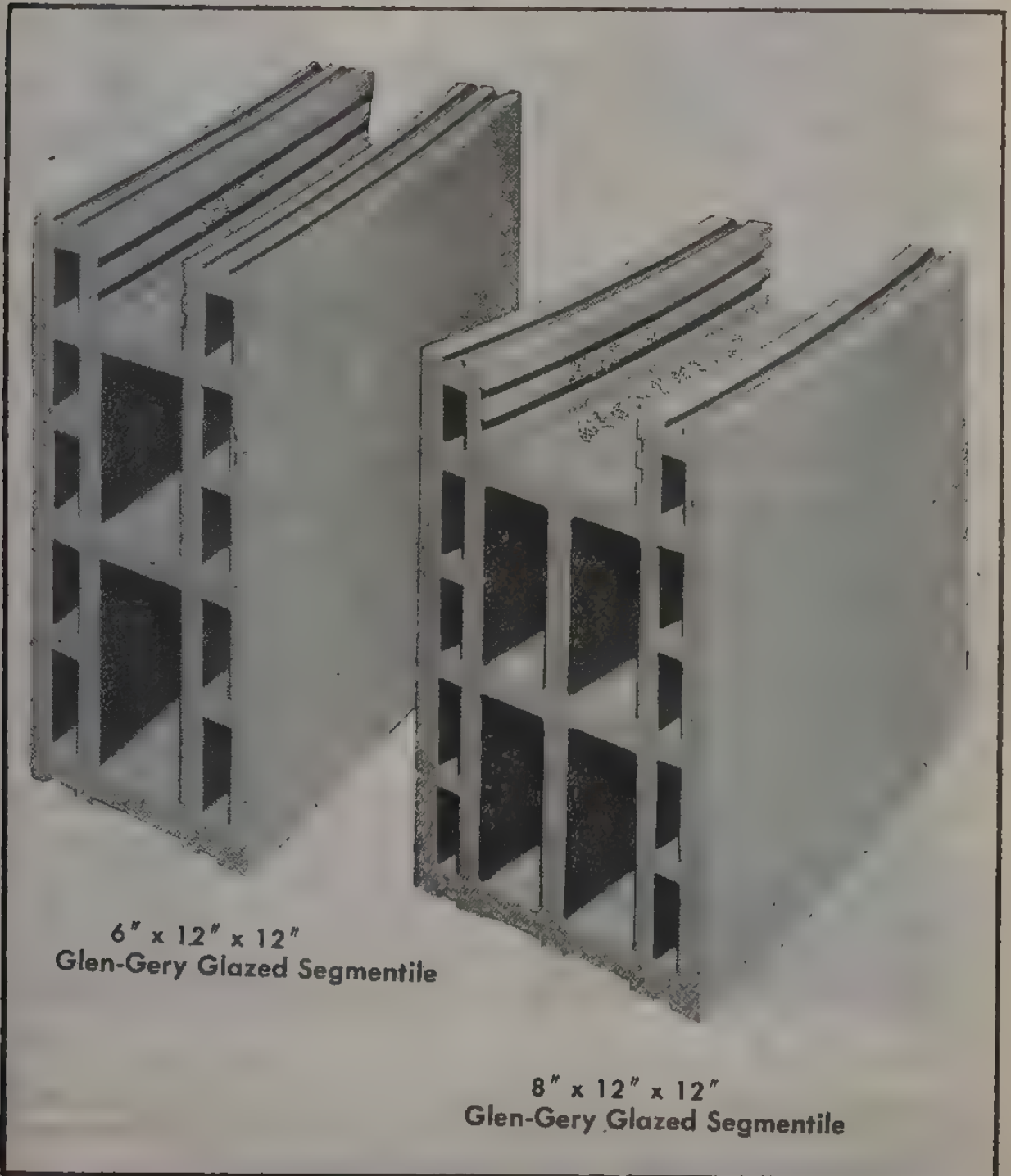
Based upon round rods of the sizes indicated of intermediate grade steel, with rolled threads. If cut threads are used the ends must be upset, or the spacing be closer. Unit tensile stress 20,000 psi (c)

Distance from top of silo in feet	Lateral Pressure of silo in psf (c)	(a) Hoop Spacing in Inches for 5/16 Inch Diameter Rods — Silo Diameter in feet						Hoop Spacing in Inches for 1/2 or 5/16 Inch Diameter Rods — Silo Diameter in feet					
		10	12	14	16	18	20	10	12	14	16	18	20
2½	12	30	30	30	30	30	30	30	30	30	30	30	30
5	33	30	30	30	30	30	30	30	30	30	30	30	30
7½	60	30	30	30	30	30	30	30	30	30	30	30	30
10	91	30	30	30	30	30	30	30	30	30	30	30	30
12½	125	30	30	30	30	30	30	30	30	30	30	30	30
15	162	30	30	30	30	30	30	30	30	30	30	30	30
17½	203	30	30	30	30	30	30	30	30	30	30	15	15
20	246	30	30	30	30	15	15	30	30	15	15	15	15
22½	294	30	30	30	15	15	15	30	15	15	15	15	15
25	340	30	30	15	15	15	15	15	15	15	15	15	15
27½	388	30	15	15	15	15	15	15	15	15	15	15	15
30	440	15	15	15	15	15	10	15	15	15	15	15	10
32½	495	15	15	15	15	10	10	15	15	15	15	10	10
35	550	15	15	15	10	10	10	15	15	15	10	10	10
37½	609	15	15	10	10	10	10	15	15	10	10	10	10
40	668	15	15	10	10	10	7½	15	15	10	10	10	7½
42½	725	15	10	10	10	7½	7½	15	10	10	10	7½	7½
45	793	15	10	10	7½	7½	7½	15	10	10	7½	7½	7½
47½	855	10	10	10	7½	7½	6	10	10	10	7½	7½	6
50	925	10	10	7½	7½	7½	6	10	10	7½	7½	7½	6
52½	990	10	10	7½	7½	6	6	10	10	7½	7½	6	6
55	1055	10	7½	7½	6	6	6	10	7½	7½	6	6	6
57½	1110	10	7½	7½	6	6	5	10	7½	7½	6	6	5
60	1200	7½	7½	6	6	5	5	7½	7½	6	6	5	5

For spacings above zig-zag line use ½" rods. For spacings below zig-zag line use 9/16" rods.
Psi denotes pounds per sq. in., psf denotes pounds per sq. ft. * A.C.I. 714

of malleable cast iron or steel. The strength of the lug should be such that the ultimate strength of the hooping to be used with it can be developed by the lug in place. For silos up to and including 10′-0″ in diameter, at least two lugs per hoop should be used; from 10′-0″ to 16′-0″, at least 3 lugs per hoop should be used; and for diameters from 16′-0″ to 22′-0″, at least 4 lugs per hoop should be used.

On a new silo a final retightening of the reinforcing rods should be made 5 to 7 days after the silo is erected.



Tile Storage Bins

Glen-Gery storage bin and silo tile are clay, burned at a temperature of over 2,000 degrees and are salt glazed. They are made with a channel space at the top of each tile which permits the use of steel bands or reinforcing bars in each row of tile, amount of steel being proportioned to the amount of pressure, which is greatest at the bottom of the bin and decreases at the top.

These tile are furnished 12" high, 12" long and 6" and 8" thick, and it requires one tile per sq. ft. of wall, excluding the mortar joints which generally average ½" thick.

Mortar Required for Tile Storage Bins.—Pure portland cement mortar should be used for laying all tile to make the strongest possible wall. Including mortar required to fill the channel space at the top of each tile, it will require approximately 9 cu. ft. of mortar for 6" thick tile and 12 cu. ft. for 8" thick tile per 100 sq. ft. of wall.

Labor Laying Silo Tile.—When laying-up circular walls of 6"x12"x12" salt glazed tile, a mason should set 110 to 125 sq. ft. of tile per 8-hr. day, and will require one laborer to each mason.

When circular bin walls are laid up with 8" x 12" x 12" salt glazed tile, a mason should lay 90 to 100 sq. ft. of tile per 8-hr. day with a laborer helping full time.

Cost of 100 Sq. Ft. of 6"x12"x12" Natco Storage Bin Tile Wall

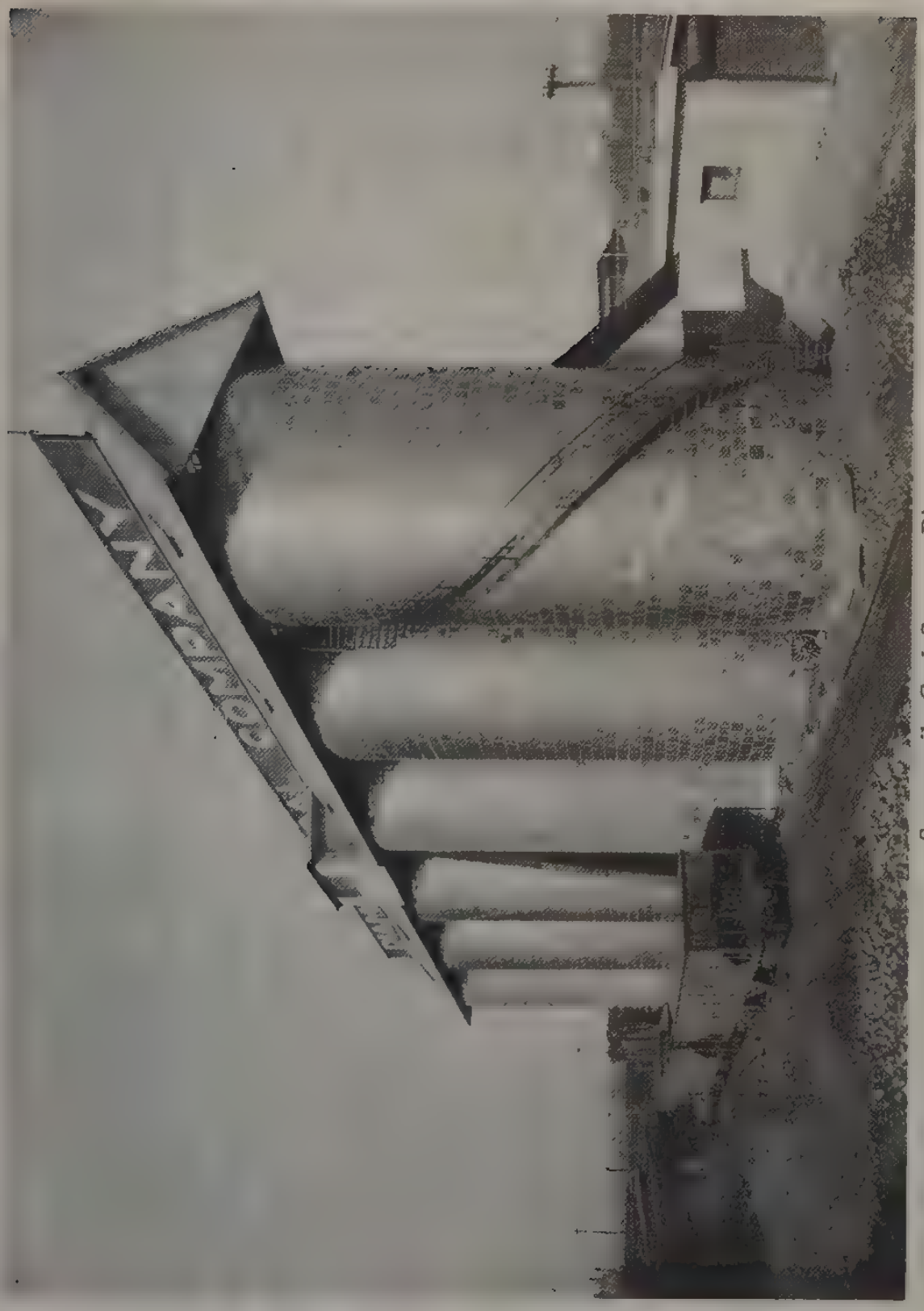
	Hours	Rate	Total	Rate	Total
95 pcs. 6"x12"x12" tile		$.....	$.....	$0.65*	$ 61.75
9 cu. ft. cement mortar		.....	.....	.75	6.75
Mason	7.0	.....	.....	7.10	49.70
Labor	7.0	.....	.....	5.00	35.00
Cost per 100 sq. ft.	14.0		$.....		$153.20
Cost per sq. ft.			.....		1.532

Cost of 100 Sq. Ft. of 8x"12"x12" Natco Storage Bin Tile Wall

	Hours	Rate	Total	Rate	Total
95 pcs. 8"x12"x12" tile.		$.....	$.....	$0.92*	$ 87.40
12 cu. ft. cement mortar		.....	.....	.75	9.00
Mason	8.5	.....	.....	7.10	60.35
Laborer	8.5	.....	.....	5.00	42 50
Cost per 100 sq. ft.	17.0	.....	$.....		$199.25
Cost per sq. ft.			.....		1.993

Reinforcing Steel.—Reinforcing steel will have to be added for each row of tile, according to size and weight of contents.

*Tile costs subject to change. Check with manufacturer.



Segmentile Coal Storage Bins

It is impossible to give the amount of reinforcing steel required, as this will vary with the height of the storage bins and the pressure exerted by the contents and should be figured separately for each job.

Capacities of Storage Bins of Various Diameters—Per Foot of Height

DIAMETERS			10′ Dia.	12′ Dia.	14′ Dia.	16′ Dia.	18′ Dia.	20′ Dia.	22′ Dia.	24′ Dia.
Cubical Contents—		Cu. Ft.	78.54	113.10	153.94	201.06	254.47	314.16	380.13	452.39
Sand, Crushed Stone, etc.		Cu. Yds.	2.91	4.18	5.70	7.44	9.42	11.63	14.08	16.75
Crushed Stone or Sand	(100 lbs. per cu. ft.)	Tons	3.93	5.65	7.70	10.05	12.72	15.71	19.01	22.62
Coal—Anthracite	(52 lbs. per cu. ft.)	Tons	2.04	2.94	4.00	5.23	6.62	8.17	9.88	11.76
Coal—Bituminous	(50 lbs. per cu. ft.)	Tons	1.96	2.82	3.85	5.02	6.36	7.85	9.50	11.31
Cinders	(45 lbs. per cu. ft.)	Tons	1.77	2.54	3.46	4.52	5.72	7.07	8.55	10.18
Salt	(48 lbs. per cu. ft.)	Tons	1.88	2.71	3.69	4.82	6.11	7.54	9.12	10.86
Lime—Unslaked	(53 lbs. per cu. ft.)	Tons	2.08	3.00	4.08	5.33	6.74	8.32	10.07	11.99
Lime—Hydrated	(40 lbs. per cu. ft.)	Tons	1.57	2.62	3.08	4.02	5.09	6.28	7.60	9.05
Cement in Bulk	(94 lbs. per cu. ft.)	Tons	3.69	5.32	7.23	9.45	11.96	14.76	17.87	21.26
Grain	(1 bu. = 1.24445 cu. ft.)	Bushels	63.11	90.88	123.70	161.56	204.48	252 45	305.46	363.52
Liquid	(231 cu. in.)	Gallons	587.52	846.05	1151.55	1504.03	1903.57	2350.08	2843.57	3384.11
Interspace between 4 bins		Cu. Ft.	46.97	61.27	77.28	95.02	114.47	135 64	158.52	183.12
Interspace between 4 bins		Bushels	37.38	49.28	62.14	76.36	92.04	109.00	127.38	147.15

TO USE TABLE:—Example:

How many tons of hard coal will a bin 20′ in diameter and 25′ high hold—From table, 8.17 x 25′ = 204 tons capacity.

Concrete Manhole and Catch Basin Block

Concrete manhole and catch basin block are radial concrete units used for building circular manhole or catch basins in storm or sanitary sewers. The best quality units meet or exceed the specifications of the American Concrete Institute.

Size and Weight of Units.—For manholes or catch basins having 48″ inside diameter, 10 units are usually required for each course; for 42″ 9 units; 36″ 8 units, and 30″ require 7

Number of 6″x7¾″x16¾″ Double Grooved Concrete Manhole Blocks and Quantity of Mortar Required to Lay Up Manholes and Catch Basins of Various Sizes

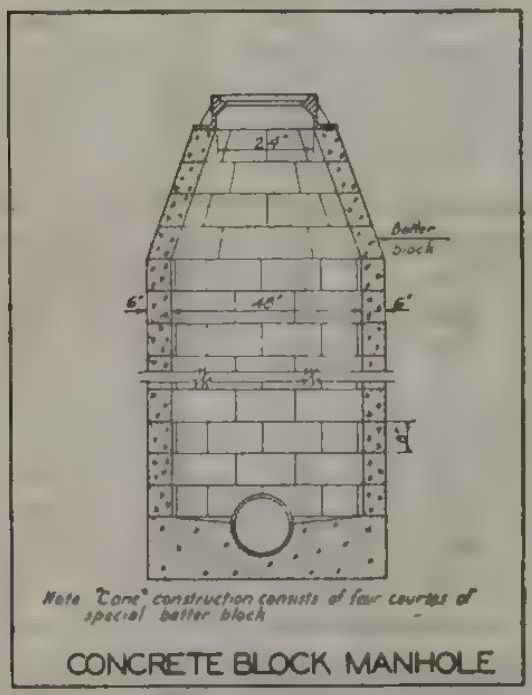
Depth of Manhole		Internal Diameter of Manhole 30″	36″	42″	48″
4 Ft.	No. Block (Cone)	8	16	24	32
	No. Block (Bbl.)	35	32	27	20
	Total	43	48	51	52
	Cu. Ft. Mortar	1½	2	2½	3
6 Ft.	No. Block (Cone)	8	16	24	32
	No. Block (Bbl.)	56	56	54	50
	Total	64	72	78	82
	Cu. Ft. Mortar	2	3	4	5
8 Ft.	No. Block (Cone)	8	16	24	32
	No. Block (Bbl.)	77	80	81	80
	Total	85	96	105	112
	Cu. Ft. Mortar	2½	3½	4½	5½
10 Ft.	No. Block (Cone)	8	16	24	32
	No. Block (Bbl.)	99	104	108	110
	Total	107	120	132	142
	Cu. Ft. Mortar	3	4	5	6
12 Ft.	No. Block (Cone)	8	16	24	32
	No. Block (Bbl.)	119	128	135	140
	Total	127	144	159	172
	Cu. Ft. Mortar	3½	5	6½	8
14 Ft.	No. Block (Cone)	8	16	24	32
	No. Block (Bbl.)	140	152	162	179
	Total	148	168	186	202
	Cu. Ft. Mortar	4	5½	7½	9½

units. However, one popular type of block requires 12 units per course in 48" structures and 9 units in 36". A block 7¾" high and 6" thick weighs approximately 50 lbs. and a block 5¾" high and 6" thick weighs approximately 35 lbs.

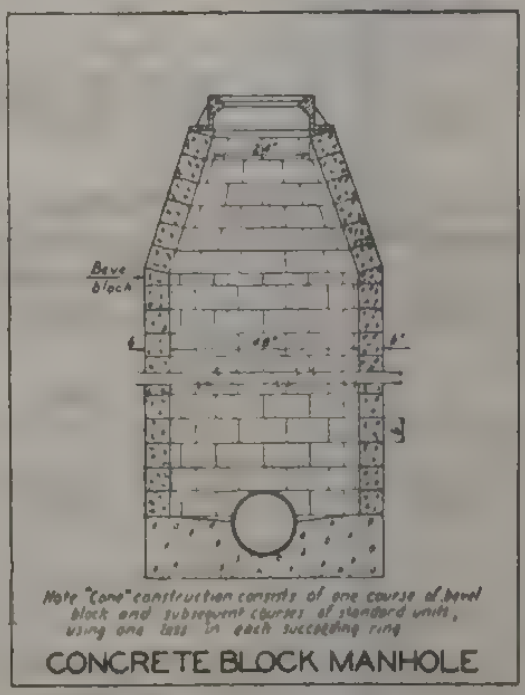
Approximate Prices of Manhole Covers and Frames

City Standard-9" Frame	$65.00
Suburban Standard-7" Frame	50.00
Precast Concrete-36" diameter	15.00
Precast Concrete-48" diameter	32.00

Method of Construction.—The concrete base is placed and then the first course of blocks is embedded at least 3" in the plastic concrete, leveling the units at once, as this construction insures a watertight joint at the base.



CONCRETE BLOCK MANHOLE


Bevel block
Note "Cone" construction consists of one course of bevel block and subsequent courses of standard units, using one less in each succeeding ring
CONCRETE BLOCK MANHOLE

Labor and Material Costs for Concrete Block Manholes and Catch Basins. -The estimated cost of labor and material for a concrete block manhole, 48" inside diameter and 8'-0" deep, is as follows:

	Hours	Rate	Total	Rate	Total
80 6"x7¾"x16¼" blocks		$.....	$.....	$0.45	$ 36.00
32 cone blocks		.....	.....	.45	14.40
8 cu. ft. 1:1:6 mortar		.....	.....	.603	4.82
Mason	7.5	.....	.....	7.10	53.25
Labor	7.5	.....	.....	5.00	37.50
Cost per manhole	15.0		$.....		$145.97

Add for excavation, backfill, concrete base and cover.

PRECAST CONCRETE JOIST FLOORS

Precast concrete joists are widely used to support concrete floors in homes, apartment buildings, office buildings, schools, hospitals and similar structures. Precast concrete joists are also extensively used for supporting concrete roof slabs for practically all types of buildings.

The design tables relate only to floors and roofs which carry relatively light loads. They are not intended for use in designing floors or roofs carrying heavy or concentrated loads, or where they are subject to heavy impact loads or to vibration of mounted machinery. These conditions impose special loading problems and to meet them floors must be designed accordingly.

The concrete joists are manufactured in a cement products plant and delivered to the job ready to set in place. The joists for each floor of a building should be laid out separately, showing size of joists, spacing, etc., which varies from 20 to 33 inches, depending upon depth of joists, span, floor load, etc.

To develop maximum strength, a reinforced concrete slab 2 to 2½" thick is placed over the tops of the joists with the joists em-

Setting Precast Concrete Joists

bedded into the concrete slab to a depth of ½ to ¾-inch. Effective bond shall be obtained between the joists and slab. Concrete for both joists and slab shall have an average compressive strength

of not less than 3,750 lbs. per sq. in. at age of 28 days, which is roughly the equivalent of 1:1.6:2.6 concrete.

Floors made of precast joists mortised or embedded into a monolithic floor placed or poured on the job are called "Precast joist cast-in-place concrete slab" floors.

Floors made of precast joist over which are laid precast slabs for flooring are called "Precast joist and slab" concrete floors.

Concrete joists are manufactured 6, 8, 10, 12 and 14 inches deep and various strength requirements of each size may be obtained by increasing the amount of reinforcing steel. For instance, 8-inch concrete joists are manufactured containing from .22 to .88 sq. in. of reinforcing bars at the bottom of the joists and $\frac{3}{8}$" round reinforcing bars at the top, with $\frac{1}{4}$" round steel stirrups spaced according to the load requirements of the particular job. The strength of 10, 12, and 14-inch joists is determined in the same manner.

Notes for Table Nos. 1, 2 and 3 on pages 603, 604 and 605.

Superimposed loads shown in tables are the loads that the floor or roof is designed to support in addition to the weights shown for the precast joists and concrete slab.

Load values are limited by maximum moment or shear and will produce deflections less than $\frac{L}{360}$, except in Table No. 3 where load values shown with an asterisk are maximum loads for a deflection of $\frac{L}{360}$. In Table No. 3 load values in bold face type are limited only by maximum moment and shear and will produce deflections greater than $\frac{L}{360}$.

For Table Nos. 1 and 2, one row of bridging should be used at midspan in residential floor construction having spans over 20 ft. and in all other floor construction having spans over 16 ft. Bridging is not usually required for roof construction.

For Table No. 3, one row of bridging should be used at midspan for all floor construction having spans over 16 ft. Bridging is usually not required for roof construction.

For floor or roof construction shown in Table Nos. 1 and 3, no shoring is required during construction.

For floor and roof construction shown in Table No. 2, shoring at midspan is required during construction and must remain in place until the concrete has reached its required strength.

Bar sizes are given in numbers based on the number of eighths of an inch included in the nominal diameter of the bars as specified in ASTM A305.

Table 1 - Joists and Slab Designed as T-Beams

No shoring used during construction

See Notes on Tables, page 602

Joist size in	Size of deformed reinforcing bars Top	Bot	Wt. of joist and slab psf	Slab thickness in	Joist spacing c. to c in	Superimposed loads = psf / Clear span = ft. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	#3	#5	34	2	20		113	88	69	53	40	30								
			32	2	24	118	90	69	53	40	29									
			32	2	27	101	76	57	42	31										
			37	2½	30	85	61	43	29											
			36	2½	33	74	52	36	23											
	#3	#6	34	2	20				113	91	73	59								
			32	2	24			113	90	72	57	45								
			32	2	27		122	96	75	59	46	36								
			37	2½	30	139	106	81	61	46	33	22								
			36	2½	33	123	93	70	53	38	26									
	#3	#7	34	2	20					137	113	94								
			32	2	24				134	110	90	74								
			32	2	27				115	93	76	61								
			37	2½	30			125	99	78	61	48								
			36	2½	33		128	111	87	68	53	40								
10	#3	#6	37	2	20					124	103	85	70	57	47	38				
			35	2	24				122	99	81	66	53	43	34	27				
			34	2	27			131	105	85	69	55	44	35	27					
			39	2½	30			113	89	70	54	41	31	22						
			38	2½	33		128	100	78	60	46	34	25							
	#3	#7	37	2	20							129	109	92	78	66				
			35	2	24						124	103	87	72	61	50				
			34	2	27					129	107	89	74	61	51	42				
			39	2½	30				137	111	90	73	59	47	37	28				
			38	2½	33				121	98	79	63	50	39	30	22				
	#3	#8	37	2	20									134	115	99				
			35	2	24								125	107	91	78				
			34	2	27							127	108	92	78	66				
			39	2½	30					138	125	110	91	76	63	52				
			38	2½	33					122	111	97	80	66	54	44				
12	#3	#6	44	2	20						126	104	86	71	59	48	39	31		
			41	2	24					123	100	83	68	55	44	35	27			
			39	2	27				131	106	87	70	57	46	36	28				
			43	2½	30				113	90	72	57	44	33	24					
			42	2½	33			126	99	79	62	48	36	27						
	#3	#7	44	2	20								135	115	97	83	70	59	50	42
			41	2	24							128	108	91	77	64	54	45	37	30
			39	2	27						133	111	93	78	65	54	45	37	30	23
			43	2½	30						115	95	78	63	51	41	32	25		
			42	2½	33					124	101	82	67	54	43	34	26			
	#3	#8	44	2	20											123	107	93	81	69
			41	2	24									133	114	98	85	73	62	53
			39	2	27								135	115	99	85	72	62	52	44
			43	2½	30								117	98	83	69	58	48	39	32
			42	2½	33							123	103	86	72	60	49	40	32	25
	#3	#9	44	2	20													131	115	102
			41	2	24											137	120	105	92	80
			39	2	27										137	119	103	90	78	68
			43	2½	30									138	118	101	87	74	63	54
			42	2½	33									122	104	89	75	64	54	45

Table 2 • Joists and Slab Designed as T-Beams

Shoring used at midspan during construction

See Notes on Tables, page 602

Joist size	Size of deformed reinforcing bars		Wt. of joist and slab	Slab thickness	Joist spacing c. to c.	Superimposed loads = psf / Clear span = ft.														
in.	Top	Bot.	psf	in.	in.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	#3	#5	34	2	20		124	99	79	64	51	41								
			32	2	24	128	100	80	63	50	39	30								
			32	2	27	111	86	67	52	41	31									
			37	2½	30	100	78	58	44	33	24									
			36	2½	33	89	67	50	38	28										
	#3	#6	34	2	20				123	102	84	70								
			32	2	24			123	100	82	67	55								
			32	2	27		133	106	86	70	57	46								
			37	2½	30		121	96	76	61	[illegible]	[illegible]								
			36	2½	33	138	108	85	67	53	42	32								
	#3	#7	34	2	20						124	105								
			32	2	24					120	101	85								
			32	2	27				126	104	87	72								
			37	2½	30				115	94	77	63								
			36	2½	33			126	102	83	68	55								
10	#3	#6	37	2	20					133	112	94	79	66	55	46				
			35	2	24				130	108	89	75	62	51	42	35				
			34	2	27				113	93	77	63	52	43	35	28				
			39	2½	30			125	101	82	66	53	43	34	26					
			38	2½	33			112	90	72	58	46	37	29						
	#3	#7	37	2	20								118	101	87	75				
			35	2	24						132	112	95	81	69	59				
			34	2	27					137	115	97	82	69	59	50				
			39	2½	30					123	102	85	71	59	49	40				
			38	2½	33				134	110	91	75	62	52	42	35				
	#3	#8	37	2	20										124	109				
			35	2	24								133	115	100	87				
			34	2	27							136	116	100	86	75				
			39	2½	30						137	122	104	88	75	64				
			38	2½	33					134	123	109	92	78	66	56				
12	#3	#6	44	2	20						134	112	95	80	67	56	47	39	32	26
			41	2	24					130	109	90	75	63	52	43	35	29		
			39	2	27					114	94	78	65	54	44	36	29			
			43	2½	30				124	101	83	67	55	44	35	28				
			42	2½	33			136	110	89	72	58	47	37	29					
	#3	#7	44	2	20									123	106	92	79	68	59	50
			41	2	24							136	116	99	84	72	62	53	45	38
			39	2	27							119	101	86	73	62	53	44	37	31
			43	2½	30						126	105	89	75	63	52	43	35	29	
			42	2½	33					135	112	93	78	65	54	44	36	29		
	#3	#8	44	2	20											133	116	102	90	79
			41	2	24										123	106	93	81	70	61
			39	2	27									123	106	92	80	69	61	52
			43	2½	30								128	109	94	81	69	59	50	43
			42	2½	33							134	114	97	83	71	60	51	43	36
	#3	#9	44	2	20														125	111
			41	2	24												128	113	100	88
			39	2	27											127	111	98	86	76
			43	2½	30										129	113	98	85	75	65
			42	2½	33									133	115	99	86	75	65	56

Table 3 • Joists Designed as Independent Beams

No shoring used during construction

See Notes on Tables page 602

Joist size in.	Size of deformed reinforcing bars: Top	Bot.	Wt. of joist and slab psf	Joist spacing c. to c. in.	Superimposed loads = psf / Clear span = ft. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	#3	#5	34	20	112	86	67	52	40	31									
			32	24	89	68	52	40	30	21* **22**									
			32	27	76	57	43	32	23										
	#4	#6	34	20			106	85	69	49* **56**	23* **45**								
			32	24		107	85	67	54	30* **43**	8* **34**								
			32	27		92	72	56	42* **44**	16* **35**									
	#6	#7	34	20					103	69* **85**	39* **71**								
			32	24				100	79* **82**	46* **67**	21* **55**								
			32	27			106	86	60* **69**	30* **56**	8* **46**								
10	#3	#6	37	20					100	82	68	56	46	26* **37**					
			35	24				98	79	64	52	42	29* **34**						
			34	27			104	84	68	54	44	35							
	#5	#7	37	20							104	88	70* **74**	43* **63**	21* **53**				
			35	24						99	82	69	46* **58**	23* **48**	5* **40**				
			34	27					102	85	70	57* **59**	32* **49**	12* **40**	— **33**				
	#6	#8	37	20									85* **107**	56* **93**	32* **80**				
			35	24								89* **100**	59* **85**	34* **73**	14* **63**				
			34	27							102	70* **86**	43* **73**	22* **62**	4* **53**				
12	#3	#6	44	20						105	87	72	60	49	40	32	26		
			41	24					102	83	68	56	45	36	29	23			
			39	27				109	88	72	58	47	38	30	23				
			43	30				90	71	57	45	35	26						
			42	33			100	79	62	49	38	29							
	#3	#7	44	20									96	81	69	58	49	39* **41**	19* **34**
			41	24							106	89	75	63	53	44	37	20* **30**	
			39	27							92	77	65	54	45	37	28* **30**	10* **24**	
			43	30						91	75	61	50	40	32	21* **25**			
			42	33					98	80	65	53	43	34	26				
	#4	#8	44	20											103	90	75* **78**	50* **67**	28* **58**
			41	24										95	81	70	50* **60**	28* **52**	10* **44**
			39	27									96	82	70	60	37* **51**	18* **44**	2* **37**
			43	30								93	78	66	55	30* **46**	9* **38**	— **31**	
			42	33							97	82	68	57	41* **47**	19* **39**	— **32**		

Concrete Joists Designed as Independent Beams.—Where concrete joists are designed to be used with precast concrete slabs, so that the slab does not form a part of the beam, it is necessary to use more reinforcing steel in the beams, which increases their cost considerably.

For instance 8″ beams having ⅜″ top bars and ⅝″ bottom bars are used for spans 10 to 15 ft.; ½″ top bars and ¾″ bottom bars for spans 11 to 16 ft., also joists using ¾″ top bars and ⅞″ bottom bars for spans 12 to 16 ft. requiring heavier loads.

Ten inch joists having ⅜″ top bars and ¾″ bottom bars are used for spans 12 to 19 ft. ⅝″ top bars and ⅞″ bottom bars for spans 14 to 20 ft.; and ¾″ top bars and 1″ bottom bars for spans 16 to 20 ft. required to carry heavier loads.

Twelve inch joists having ⅜″ top bars and ¾″ bottom bars are used for spans 12 to 22 ft.; ⅜″ top bars and ⅞″ bottom bars for spans 14 to 24 ft. and ½″ top bars and 1″ bottom bars for spans 16 to 24 ft. required to carry heavier loads.

These beams require from 1 to 2 lbs. of reintorcing steel per lin. ft. more than the T-beams and consequently cost 10 to 15 cts. per lin. ft. more than the T-beam joists.

Precast concrete joists are manufactured of Haydite, Waylite, Celocrete and other lightweight aggregate, also of ordinary aggregate consisting of gravel or crushed stone and sand.

Weight of Precast Concrete Joists, Ordinary Aggregate

Size of Joist In.	Length of Joist in Feet					
	10	12	14	16	18	20
8	190	228	266	304		
10	230	276	322	368	414	460
12	350	420	490	560	630	700

Cost of Precast Concrete Joists.—The cost of precast concrete joists will vary with the size of joists, amount of reinforcing steel required, size of job, locality, etc.

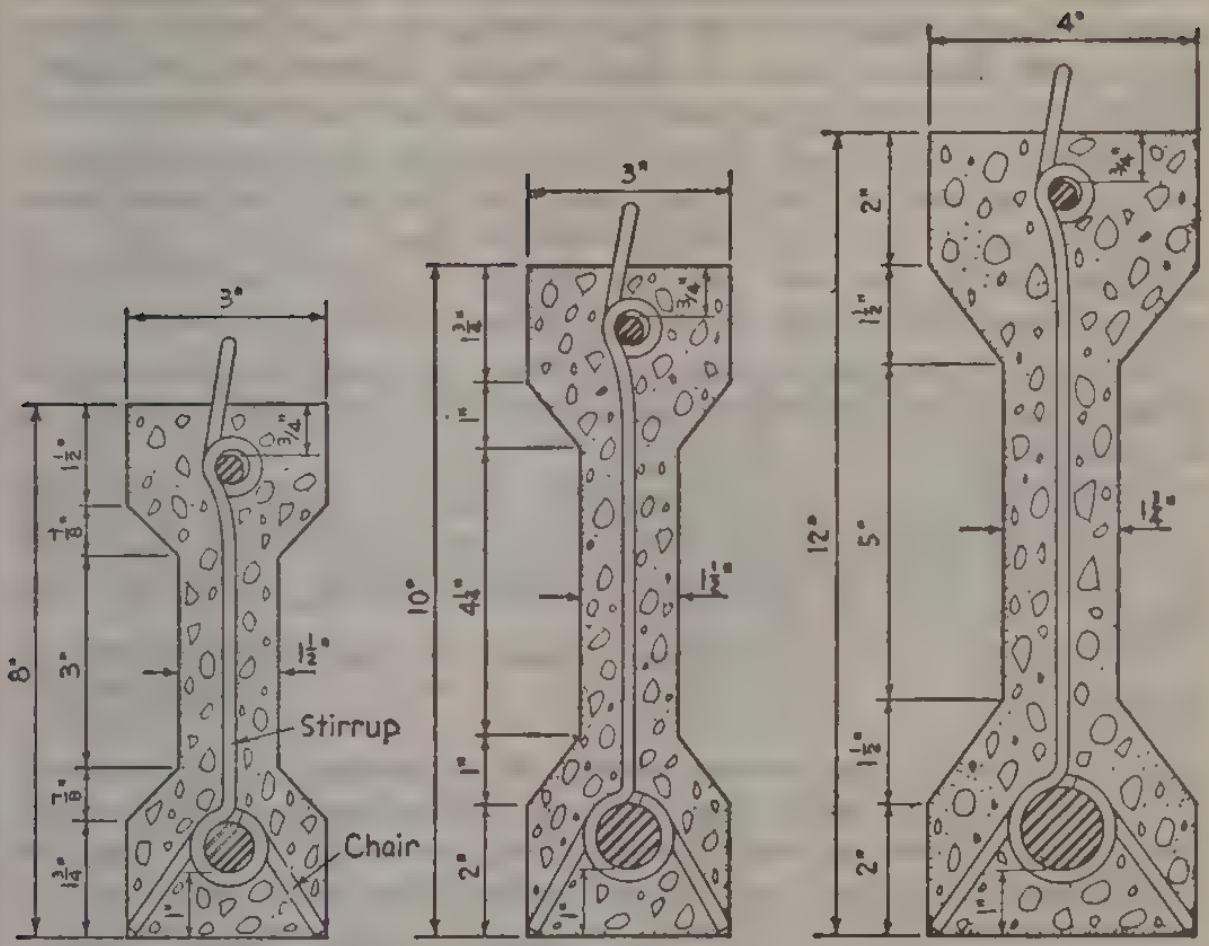
Inasmuch as precast concrete joists are always manufactured in a concrete products plant, it is important to obtain definite prices for each particular job.

Approximate Prices per Lin. Ft. for Precast Concrete Joists.—

8-Inch Joists	10-Inch Joists	12-Inch Joists	14-Inch Joists
80 cts. to $1.00	85 cts. to $1.10	$1.00 to $1.25	$1.40 to $1.65

Where the concrete joists are designed as independent beams for use with precast concrete floor or roof slabs, add from 10 to 15 cts. per lin. ft. to the above prices to allow for the extra reinforcing steel required.

Labor Setting Precast Concrete Joists.—As long as the joist is not too heavy to handle by four men or in some cases by



	8" Joist	10" Joist	12" Joist
Sectional area sq.in.	18.2	22.1	33.4
Average weight (as used in Tables 1-3) lb. per lin. ft.	19	23	35

Sizes and Weights of Precast Concrete Floor Joists.

light derricks, the precast joist is more economical than one which is cast in place. The economical limits of largeness of precast joists has not been established, although at the present time they are obtainable to a depth of 14" and 36'-0" long. Such a joist weighs approximately 1,150 to 1,330 lbs. if made of lightweight aggregate—they fall within the weight where erection by machinery is necessary.

On every job there should be a joist setting plan, prepared by an architect or engineer, as this will expedite setting the joists on the job.

Where smaller size joists are used, two men can carry the joists from the stock pile to the building and set them in place, while with heavier joists it may require 4 to 6 men to carry the joists to the building and place them on the wall.

Where joists are used on the second floor, two men will probably be required to carry the joists into the building and 3 men above to hoist the joists to the second floor. If the joists are not too heavy for two men to handle, a rope can be slipped around each end of the joist and lifted to the second floor.

After the joists have been placed on the wall, it will require some additional time for exact spacing of the joists, placing headers, etc.

Where the joists can be handled and set by 2 men, it will require 6 to 8 min. to carry one joist from stock pile (not over 50 ft.) and set it on the wall, at the following labor cost per joist:

	Hours	Rate	Total	Rate	Total
Labor	0.23	$.....	$.....	$5.00	$1.15

If joists are hoisted to the second floor, double the above costs.

When handling and setting joists requiring 4 men to carry them to the building and set them on the wall, it will require 6 to 8 min. for 4 men, at the following labor cost per joist:

	Hours	Rate	Total	Rate	Total
Labor	0.47	$.....	$.....	$5.00	$2.35

If joists are hoisted to the second floor, double the above costs.

When handling and setting 12" joists up to 24-ft. long, requiring 6 men to handle and set same, it will require 6 to 8 min. for 6 men, at the following labor cost per joist:

	Hours	Rate	Total	Rate	Total
Labor	0.7	$.....	$.....	$5.00	$3.50

If joists are hoisted to the second floor, double the above costs.

On jobs having sufficient joists to warrant the use of a hydraulic crane, and using iron workers to set the joists instead of laborers, the cost of setting joists should average as follows:

Labor setting one 8" Concrete Joist:

	Hours	Rate	Total	Rate	Total
Crane and operator	0.10	$.....	$.....	$20.00	$2.00
Iron workers	0.20	.....	.....	7.10	1.42
Cost per joist	0.30		$.....		$3.42

Labor setting one 10" Concrete Joist:

	Hours	Rate	Total	Rate	Total
Crane and operator	0.12	$.....	$.....	$20.00	$2.40
Iron workers	0.24	.....	.....	7.10	1.70
Cost per joist	0.36		$.....		$4.10

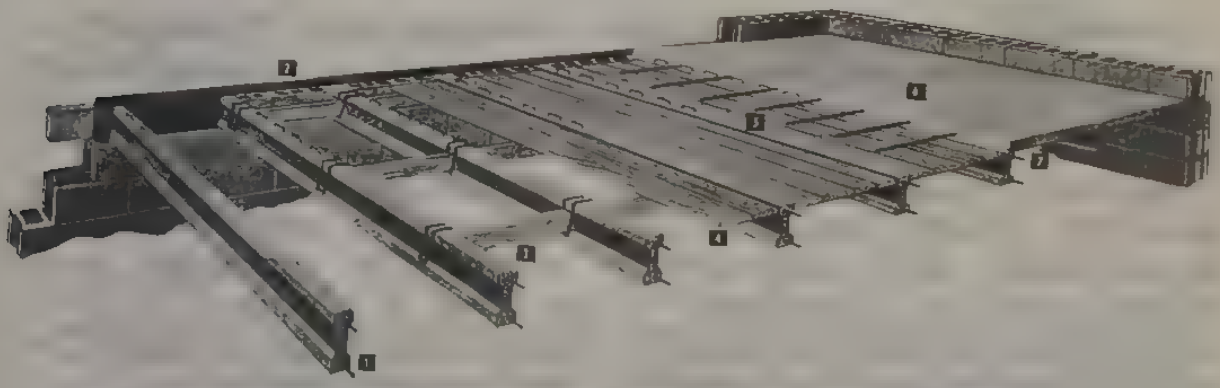
Labor setting one 12" concrete joist:

	Hours	Rate	Total	Rate	Total
Crane and operator	0.15	$.....	$.....	$20.00	$3.00
Iron workers	0.30	.....	.....	7.10	2.13
Cost per joist	0.45		$.....		5.13

Wood Forms for Precast Concrete Joist Floors.—The reinforced concrete floor slab used with precast concrete joists is usually 2 to 2½ inches thick, and the joists are spaced from 20 to 33 inches apart, so that very light formwork is sufficient.

The formwork usually consists of short pieces of 1x6 or 2x4-inch wood spreaders as shown in the illustration, cut to bear on the bottom flange of the concrete joists. These spreaders are placed between the concrete joists, and wood floor boards of 1" sheathing or ⅝" plywood are placed on top of the spreaders to receive the concrete. The joists are usually spaced so that full width boards can be used without cutting.

The forms may often be rented but in any event all of the lumber used for floor boards can be used again in the building for subflooring, sidewall or roof sheathing, so that actually the only lumber cost is for the spreaders.



Method of Constructing Precast Concrete Joist Floors

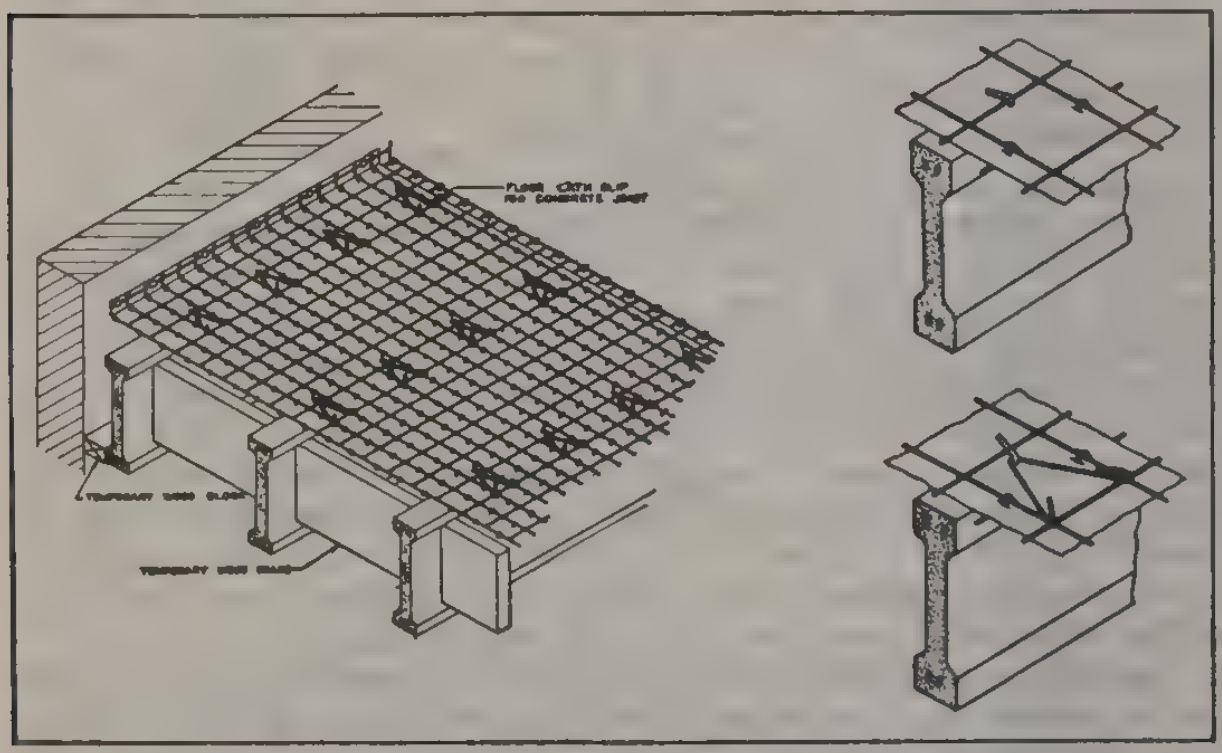
On forms of this kind, it will require about 1¼ feet of lumber b.m. per sq. ft. of floor area.

When placing forms for precast concrete joist floors, a carpenter should frame and place forms for 175 to 225 sq. ft. of floor per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	4	$.....	$.....	$6.75	$27.00
Cost per sq. ft.					.27

A laborer should remove forms from 600 to 750 sq. ft. of floor per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	1.2	$.....	$.....	$5.00	$6.00
Cost per sq. ft.....			.....		.06



Method of Constructing Precast Concrete Joist Floors Using Paper-Backed Floor Lath for Permanent Form Material

Permanent Forms for Precast Concrete Joist Floors.—Permanent type forms, not requiring removal, are being widely used in precast concrete joist floor construction, especially for work such as floors over crawl spaces, tunnels, etc., where removal of wood forms would be difficult and expensive. Form materials usually used for this purpose are of two kinds—paper-backed floor lath, such as "Steeltex*" or corrugated steel sheets, such as "Corruform**," described in Chapter 8. With Corruform, reinforcing steel or wire mesh must be added to satisfy flexure and temperature steel requirements.

Steeltex* Forms for Precast Concrete Joist Floors.—Steeltex is a welded wire mesh with a waterproofed paper backing attached. The paper backing serves as the form and the mesh as the reinforcing for thin, short span concrete floor slabs. When concrete is placed, the paper backing sags away from the mesh to the limit of the stitch wires thereby placing the reinforcing mesh at the proper position for encasement in the slab.

*National Wire Products Corp. Baltimore, Md.
**Granco Steel Products Company, Granite City, Ill.

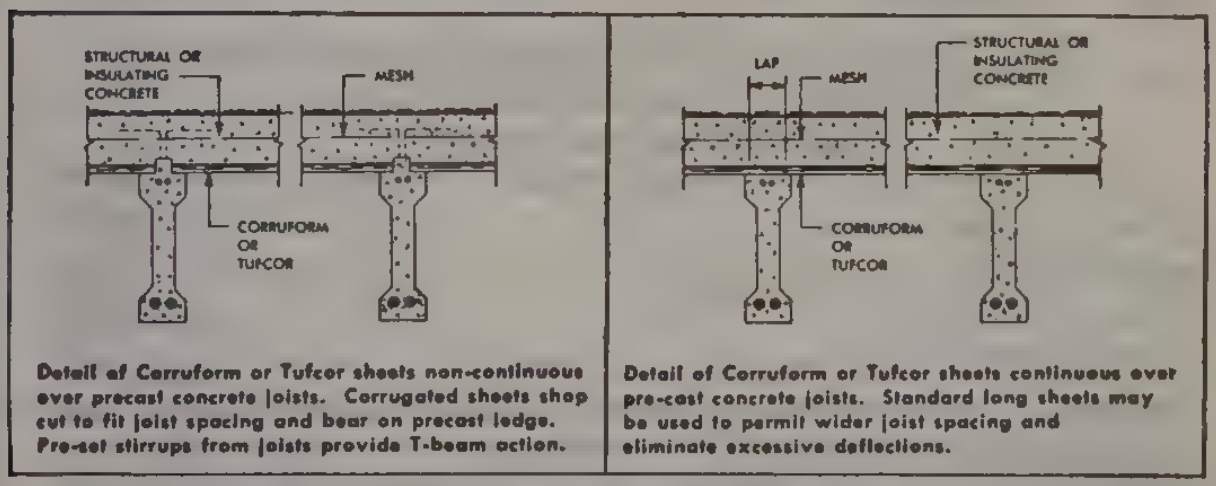
Steeltex is furnished in rolls, 4′-0″ wide and 125′-0″ long, containing 500 sq. ft. Side laps should be at least 2″ and end laps should be a minimum of 12″ occurring only over a support with no adjacent splices across the same support. In estimating, compute area of slab and add about 5 percent for laps and waste. Approximate price of Steeltex in full rolls, including necessary clips for attachment to supports, 10 cts. per sq. ft., delivered to job site. Delivered prices will vary depending upon location of job and quantity involved.

For floor slabs at or near grade level, two ironworkers working together should install about 4000 sq. ft. of Steeltex over steel joists per 8-hr. day. For slabs at higher levels, additional handling labor and hoisting must be added.

Cost of 100 Sq. Ft. Steeltex Forms for Precast Concrete Joist Floors

	Hours	Rate	Total	Rate	Total
105 sq. ft. Steeltex.....		$.....	$.....	$0.10	$10.50
Ironworker	0.4	.....	.....	7.10	2.84
Cost per 100 sq. ft.....	0.4		$.....		$13.34
Cost per sq. ft.			.....		.133

If installation work is to be sublet to a reinforcing steel setting contractor, add for subcontractor's overhead and profit which may run from 30 to 40 percent of labor cost.



Detail of Corruform or Tufcor sheets non-continuous over precast concrete joists. Corrugated sheets shop cut to fit joist spacing and bear on precast ledge. Pre-set stirrups from joists provide T-beam action.

Detail of Corruform or Tufcor sheets continuous over pre-cast concrete joists. Standard long sheets may be used to permit wider joist spacing and eliminate excessive deflections.

Two Methods of Constructing Precast Concrete Joist Floors Using Corrugated Steel Permanent Forms

Corruform* Forms for Precast Concrete Joist Floors.—There are two methods of using Corruform for precast concrete joist floors. See illustration.

Standard length Corruform—6′-3″ to 31′-9″ in 6″ increments

*Granco Steel Products Company, Granite City, Ill.

—may be laid continuous over joist tops with end laps occurring only over supports and no adjacent laps over same joist.

Corruform also may be installed between joists, so that tops of joist and protruding stirrups are encased in slab concrete, providing T-beam action. For this method, joists should be precast with ledges on the top edges to furnish support for Corruform sheets.

Side laps for standard Corruform should be one corrugation and end laps a minimum of 2". For estimating purposes, compute area of floor slab placed over Corruform and add 5 to 10 percent for laps and waste, depending upon the method of installation.

Approximate price of standard, uncoated Corruform is 13 cts. per sq. ft., delivered to job site. For hot-dip galvanized, add 3½ cts. per sq. ft. Delivered price will vary depending upon location of job and quantity involved.

Where Corruform is installed in continuous standard lengths over precast concrete joists for floors at or near grade level, with an area of 5,000 sq. ft. or more, a 4-man crew should place and secure 2,500 to 2,700 sq. ft. per 8-hr. day. For areas less than 5,000 sq. ft., the crew should install 2,100 to 2,300 sq. ft. per 8 hr. day. For average residential work, a 2 or 3-man crew is used, depending upon size of floor and type of building, and they can usually install a complete floor in a day's time. For slabs at higher levels, additional handling labor and hoisting must be added.

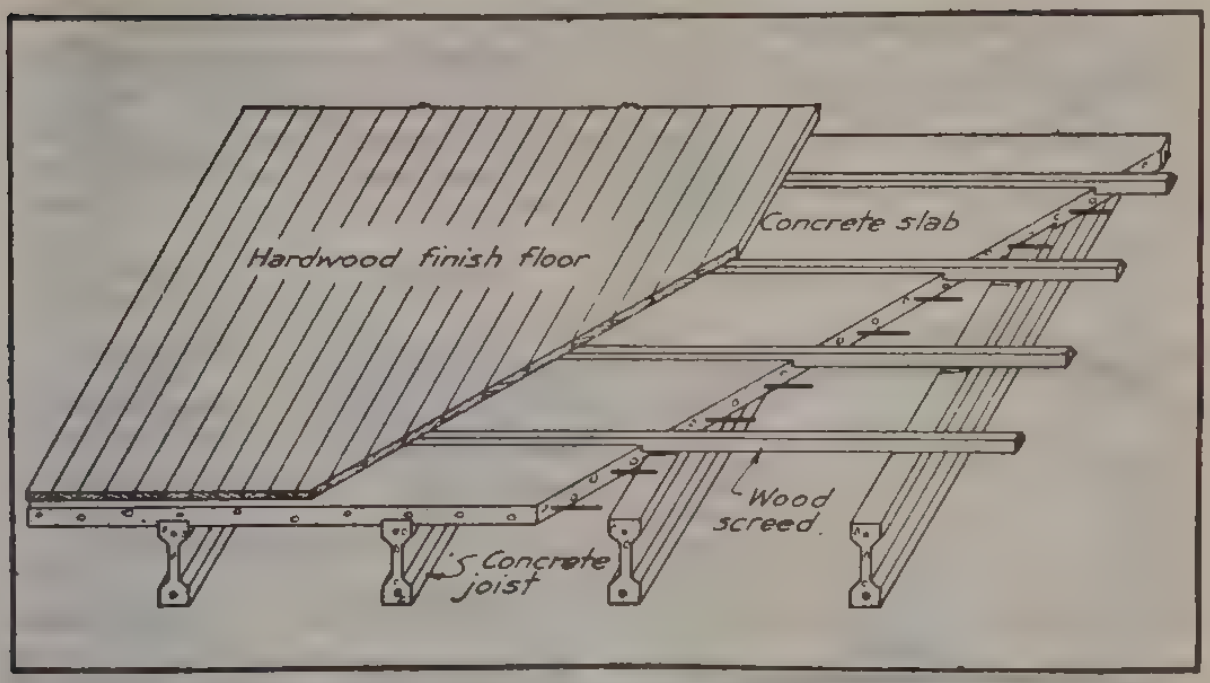
Cost of 100 Sq. Ft. of Corruform Slab Forms for Precast Concrete Joist Floors in Residential Construction

	Hours	Rate	Total	Rate	Total
110 sq. ft. Corruform		$.....	$.....	$0.13	$14.30
Ironworker	1.33	.....	.....	7.10	9.44
Cost per 100 sq. ft.	1.33		$.....		$23.74
Cost per sq. ft.					.237

Where Corruform is installed between joists, above costs should be increased about 10 percent.

Reinforcing Steel for Precast Concrete Joist Floors.—A thin slab of concrete 2 to 2½-in. thick is used with concrete joists and the reinforcing steel consists of ¼-inch round rods spaced 10 in. on centers at right angles to the joists. It requires about .33 lbs. of steel per sq. ft. or 33 lbs. per 100 sq. ft. of floor. Steel reinforcing mesh of equal effective steel area may be used instead of reinforcing rods, if desired.

A man should place about 400 lbs. of reinforcing steel per 8-hr.



Precast Concrete Joist Floors with Wood Floor Screeds

day and based on 33 lbs. per 100 sq. ft. the labor per 100 sq. ft. of floor should cost as follows:

	Hours	Rate	Total	Rate	Total
Ironworker	0.67	$.....	$.....	$7.10	$4.76
Cost per sq. ft.			.....		.048

Where welded wire mesh is used for reinforcing concrete slabs for precast concrete joist floors, a man should place 1,400 to 1,600 sq. ft. of mesh per 8-hr. day, at the following labor cost per 100 sq. ft.:

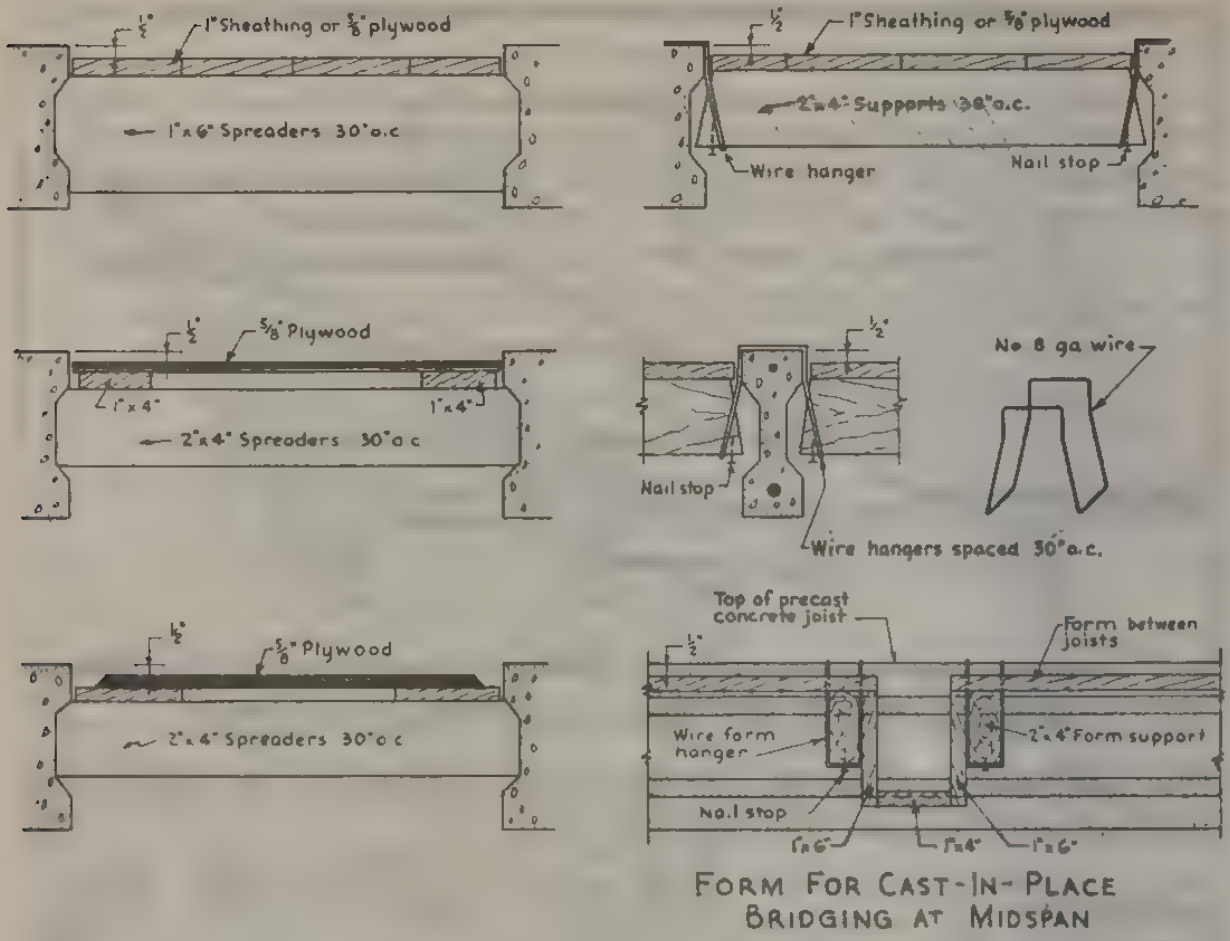
	Hours	Rate	Total	Rate	Total
Ironworker	0.53	$.....	$.....	$7.10	$3.76
Cost per sq. ft.			.....		.038

If laborers are used for setting reinforcing steel, deduct difference in rate.

Placing Concrete for Precast Concrete Joist Floors.—The labor cost of placing concrete for thin concrete floors 2 to 2½ in. thick runs somewhat higher than the cost of placing foundation concrete or concrete for heavier floors on account of the extra labor required to spread and grade so many sq. ft. of floor to place one cu. yd. of concrete.

One cu. yd. of concrete covers 162 sq. ft. of 2-in. floor or 129 sq. ft. of 2½-in. floor.

All concrete should be mixed in the proportions of 1:2½:3½ to develop a compressive strength of 3,000 lbs. per sq. in. at age of 28 days. Do not use over 6¾ gal. of water per sack of cement.



FORM FOR CAST-IN-PLACE BRIDGING AT MIDSPAN

Alternate Methods of Constructing Forms for Precast Concrete Joist Floors

Using a 6-S (1-sack) concrete mixer, it will require about 3 hrs. labor time to mix, place, spread and grade 1 cu. yd. of concrete, at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	3.0	$.....	$.....	$5.00	$15.00
Cost per sq. ft. 2" thick (162 sq. ft.)			.....		.092
Cost per sq. ft. 2½" thick (130 sq. ft.)			.....		.115

If ready-mix concrete is used for floors of this type, figure about 2 hrs. labor time to handle, place, spread and grade 1 cu. yd. of concrete at the following labor cost per cu. yd.:

	Hours	Rate	Total	Rate	Total
Labor	2.0	$.....	$.....	$5.00	$10.00
Cost per sq. ft. 2" thick (162 sq. ft.)			.....		.062
Cost per sq. ft. 2½" thick (130 sq. ft.)			.....		.077

Finish on Concrete Floors.- Where the concrete floors are required to have a smooth finish to receive resilient floor covering, wood floors laid in mastic or carpeting placed directly over the concrete, it will be necessary to monolithic trowel the

surface of the floor or apply a troweled cement topping over the rough concrete.

Cement topping is usually mixed in the proportions of 1 part cement to 2 parts sand and sufficient material for 1 cu. yd. of cement mortar should cost as follows:

	Rate	Total	Rate	Total
12.5 sacks portland cement	$.....	$.....	$1.80	$22.50
0.95 cu. yds. sand.....	.....	.....	4.00	3.80
Cost per cu. yd.....		$.....		$26.30
Cost per cu. ft. (27 cu. ft. per cu. yd.)		.....		.975
Cost per sq. ft. floor ½-in. thick (648 sq. ft. per cu. yd.)		.....		.041

For applied cement topping, 2 cement masons and a helper should place screeds, strike off, darby, float and trowel once over 800 to 1,000 sq. ft. of floor per 8-hr. day and will require one laborer to mix and place the cement topping. The labor cost per 100 sq. ft. of floor will be as follows:

	Hours	Rate	Total	Rate	Total
Cement mason	1.8	$.....	$.....	$6.50	$11.70
Helper	0.9	.....	.....	5.00	4.50
Labor, mixing and placing topping	0.9	.....	.....	5.00	4.50
Cost per 100 sq. ft.	3.6		$.....		$20.70
Cost per sq. ft.			.....		.207

Where the floor slab is finished monolithically, figure the same for finishing labor as given above, but deduct labor cost for mixing and placing topping material.

Wood Sleepers For Use With Precast Concrete Joist Floors.—Where wood floors are used with precast concrete joist floors, it will be necessary to place 2x2 or 2x3-in. wood strips or "sleepers" in the concrete for nailing the wood floors. These strips should be spaced about 16 in. on centers and should rest on top of the steel stirrups that project above the concrete joist. The sleepers are secured to the joists by wiring around the wood strip and through the top of the steel stirrups. Care must be taken when placing the concrete to see that the strips are level to receive the finish wood floors.

The floor strips should be beveled or nails driven into the sides at short intervals to provide anchorage into the concrete, otherwise after the concrete hardens and the wood strips dry out and shrink they become loose and cause squeaking floors.

Where wood strips are placed over the tops of the joists without leveling, a carpenter should place 350 to 450 lin. ft. per

8-hr. day, at the following cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.0	$.....	$.....	$6.75	$13.50
Cost per lin. ft.					.135
Cost per 100 sq. ft. (16-in. on centers)	1.5		.....	$6.75	$10.13
Cost per sq. ft.			.....		.101

Cost of 2x2-Inch Wood Floor Strips Spaced 16 Inches on Centers for 100 Sq. Ft. of Precast Concrete Joist Floors

	Hours	Rate	Total	Rate	Total
80 lin. ft. 2x2-in. strips		$.....	$.....	$0.06	$ 4.80
Carpenter	1.5			6.75	10.13
Cost per 100 sq. ft.	1.5		$.....		$14.93
Cost per sq. ft.			.....		.149

Cost of One Cu. Yd. of 1:2½:3½ Concrete for Precast Joist Floors

	Hours	Rate	Total	Rate	Total
5.88 sacks portland cement		$.....	$.....	$1.80	$10.58
21 cu. ft. gravel			.....	.15	3.15
15 cu. ft. sand		.....	.....	.15	2.25
Labor	3		.....	5.00	15.00
Cost per cu. yd.	3		$.....		$30.98
Cost per sq. ft. 2" thick (162 sq. ft.)			.....		.191
Cost per sq. ft. 2½" thick (130 sq. ft.)			.....		.238

Cost of 100 Sq. Ft. Precast Concrete Joist Floors, Using 8-Inch Concrete Joists Spaced 2'-0" on Centers and 2-Inch Cast-in-Place Concrete Floor Slab

	Hours	Rate	Total	Rate	Total
55 lin. ft 8" conc. joists		$.....	$.....	$0.80*	$44.00
Labor setting joists	1.15	.....	.....	5.00	5.75
Wood forms, 125 ft. b.m.		.....	.....	.06**	7.50
Carpenter erecting forms	4.00	.....	.....	6.75	27.00
Labor removing forms	1.20	.....	.....	5.00	6.00
33 lbs. reinforcing steel		.....	.....	.15	4.95
Ironworker	0.67	.....	.....	7.10	4.76
3.63 sacks portland cement		.....	.....	1.80	6.53
13 cu. ft. gravel			.....	.15	1.95
9.3 cu. ft. sand		.....	.....	.15	1.40
Labor placing concrete (0.617 cu. yd.)	1.85	.....	.....	5.00	9.25
Cost per 100 sq. ft.	8.87		$.....		$119.09
Cost per sq. ft.					1.191

Add cost of setting screeds and finishing floor surfaces.

*Varies according to locality and amount of reinforcing steel.

**Varies according to number of uses.

If ready-mix concrete is used, deduct cost of cement, sand and gravel as given above, and add .617 cu. yd. ready-mix concrete, also deduct 0.62 hrs. labor time mixing concrete.

For work above first floor, add labor hoisting joists and concrete.

For other than 24 inch joist spacing change number of lin. ft. of joists required and labor placing same.

If 10″ joists are used, add difference in cost of joists and add 0.6 hrs. labor setting joists.

If 12″ joists are used, add difference in cost of joists and add 1.2-hrs. labor setting joists.

Cost of 100 Sq. Ft. Precast Concrete Joist Floors, Using 8-Inch Concrete Joists Spaced 2′-6″ on Centers and 2½-Inch Cast-in-Place Concrete Floor Slab

	Hours	Rate	Total	Rate	Total
44 lin. ft. 8″ conc. joists..		$.....	$.....	$0.80*	$ 35.20
Labor setting joists	0.92	.....	.....	5.00	4.60
Wood forms, 125 ft. b.m....		.....	.....	.06**	7.50
Carpenter erecting forms..	4.00	.....	.....	6.75	27.00
Labor removing forms ...	1.20	.....	.....	5.00	6.00
33 lbs. reinforcing steel...		.....	.....	.15	4.95
Ironworker	0.67	.....	.....	7.10	4.76
4.54 sacks portland cement		.....	.....	1.80	8.17
16.2 cu. ft. gravel		.....	.....	.15	2.43
11.6 cu. ft. sand.....		.....	.....	.15	1.74
Labor placing concrete (0.772 cu. yds.)	2.32	.....	.....	5.00	11.60
Cost per 100 sq. ft.	9.11		$.....		$113.95
Cost per sq. ft.			.....		1.140

*Varies according to locality and amount of reinforcing steel required.
**Varies according to salvage value of lumber.

Add cost of setting screeds and finishing floor surfaces.

If ready-mix concrete is used, deduct cost of cement, sand and gravel as given above, and add .772 cu. yd. ready mix concrete, also deduct .77-hrs. labor time mixing concrete.

For work above first floor, add labor hoisting joists and concrete.

For other than 30 inch joist spacing change number of lin. ft. of joists required and labor placing same.

If 10″ joists are used, add difference in cost of joists and add .048-hrs. labor setting joists.

If 12″ joists are used, add difference in cost of joists, and add 0.96-hrs. labor setting joists.

Labor Handling and Placing Precast Concrete Slabs.—Precast concrete slabs are often used in conjunction with concrete joists instead of cast-in-place concrete slabs.

These slabs are ordinarily used for roofs or for floor slabs in unexcavated areas where it is either extremely difficult or impossible to remove the forms after the cast-in-place slab has been poured.

When precast slabs are used, it requires joists containing heavier reinforcing steel than where T-beam construction is used. This increases the cost of the concrete joists 10 to 15 cents per lineal foot.

Precast concrete slabs are furnished in four sizes, i.e., 2'-1"x 2'-6"x1¼"; 1'-2"x2'-1"x1¼"; 1'-0"x2'-6"x1¼" and 1'-6"x2'-1"x1¼". They are reinforced with 4"x4" No. 10 wire mesh.

When used as roof slabs, they are laid over the concrete joists with about a 1" space between the slabs. After the slabs are placed they are grouted in solid. Insulation board or roofing is applied directly over the slabs.

When used for floors, the precast slabs are placed over the joists and about 1½" of concrete is poured over the slab and either left rough or troweled to a smooth finish to receive asphalt tile, linoleum or other finish floor.

This method eliminates form cost but it requires heavier reinforced joists and it is more difficult for the mechanical trades to place their pipes than where the cast-in-place floor is used.

Up to a 14'-0" clear span requires 8" joists; to 18'-0" clear span requires 10" joists, and up to 24'-0" clear span requires 12" joists.

Precast slabs weigh 16 lbs. per sq. ft. and cost about 30 cts. per sq. ft. for jobs of 1,000 sq. ft. or more.

On smaller jobs, the men usually work in groups of two carrying and placing the precast slabs over the concrete joists.

On work on the first floor, where the precast slabs are on the floor or convenient to the place where they are to be used, two men working together should handle and set 50 to 60 pcs. (180 to 250 sq. ft.) an hour, depending upon the size of the slabs used, at the following labor cost per 100 pcs.:

	Hours	Rate	Total	Rate	Total
Labor	3.6	$.....	$.....	$5.00	$18.00
Cost per piece					.180

Add cost of carrying slabs from stock pile to floor.

If slabs are to be hoisted to the second floor, double the above costs.

Placing Precast Concrete Floor Slabs.

On large jobs where it is possible to use a hydraulic crane to lift the slabs from the ground to the second floor or roof, a crane will hoist 7 slabs at one time and place them on the floor.

After the slabs have been hoisted to the roof, one man has set as high as 60 pcs. of 2'-0"x2'-6" slabs an hour. However, this is the exception and the average is about 30 pcs. per hour.

To the above costs it will be necessary to add cost of material and labor grouting joints between slabs.

Actual Labor Costs

On a two story building on which precast concrete joists and precast concrete floor slabs were used the work was handled in the following manner. Concrete joists were 10" deep and 14'-0" long (made of lightweight aggregate and weighed 238 lbs. each), and were supported on brick walls and steel beams.

The joists were carried into the building where 2 men on the ground placed a rope sling around each end of the joists and 3 men on the second floor hoisted and placed the joists. After they were placed in their approximate positions, it was necessary to space them exactly according to plan and place all necessary headers.

The job required 51-10" joists 14'-0" long, which covered 2,080 sq. ft. of floor and the labor cost was as follows:

	Hours	Rate	Total	Rate	Total
Foreman	3.5	$.....	$.....	$5.25	$ 18.38
Labor	17.5	.....	.....	5.00	87.50
Cost setting 51 joists	21.0		$.....		$105.88
Cost per joist			.....		2.08
Cost per lin. ft. (714 lin. ft.)			.....		.148
Cost per sq. ft. of floor (2,080 sq. ft.)			.....		.051

Of the above labor time, 12.5 hrs. was carrying, hoisting and placing joists and 5 hrs. were required for accurate spacing and placing headers.

There were 2,080 sq. ft. of 2" precast concrete slabs placed over the concrete joists. The precast concrete slabs were carried into the building, hoisted with a rope sling and placed over the floor area.

The labor cost for the 2,080 sq. ft. of 2" precast slabs was as follows:

	Hours	Rate	Total	Rate	Total
Foreman	4	$.....	$.....	$5.25	$ 21.00
Labor	26	.....	.....	5.00	130.00
Total cost 2,080 sq. ft.	30		$.....		$151.00
Cost per sq. ft.			.....		.073

A man carried, hoisted and placed 80 sq. ft. of 2" precast concrete slab an hr. or 640 sq. ft. per 8-hr. day. This does not include any foreman time.

FLEXICORE* FLOOR AND ROOF SLABS

Prestressed Flexicore concrete floor and roof slabs designed in accordance with ACI 318-63 Building Code are precast in central plants with patented equipment. The cross sections and lengths of these units are indicated in Table I.

TABLE I

	SPAN	LBS. PER SQ. FT. (Based on 150 Lb. Concrete)
6" x 16"	25'	43
8" x 16"	32'	57
10" x 20"	40'	61
12" x 24"	51'	79

The amount of deflection allowed shall be consistent with the finish to be applied to the underside of the flexicore units.

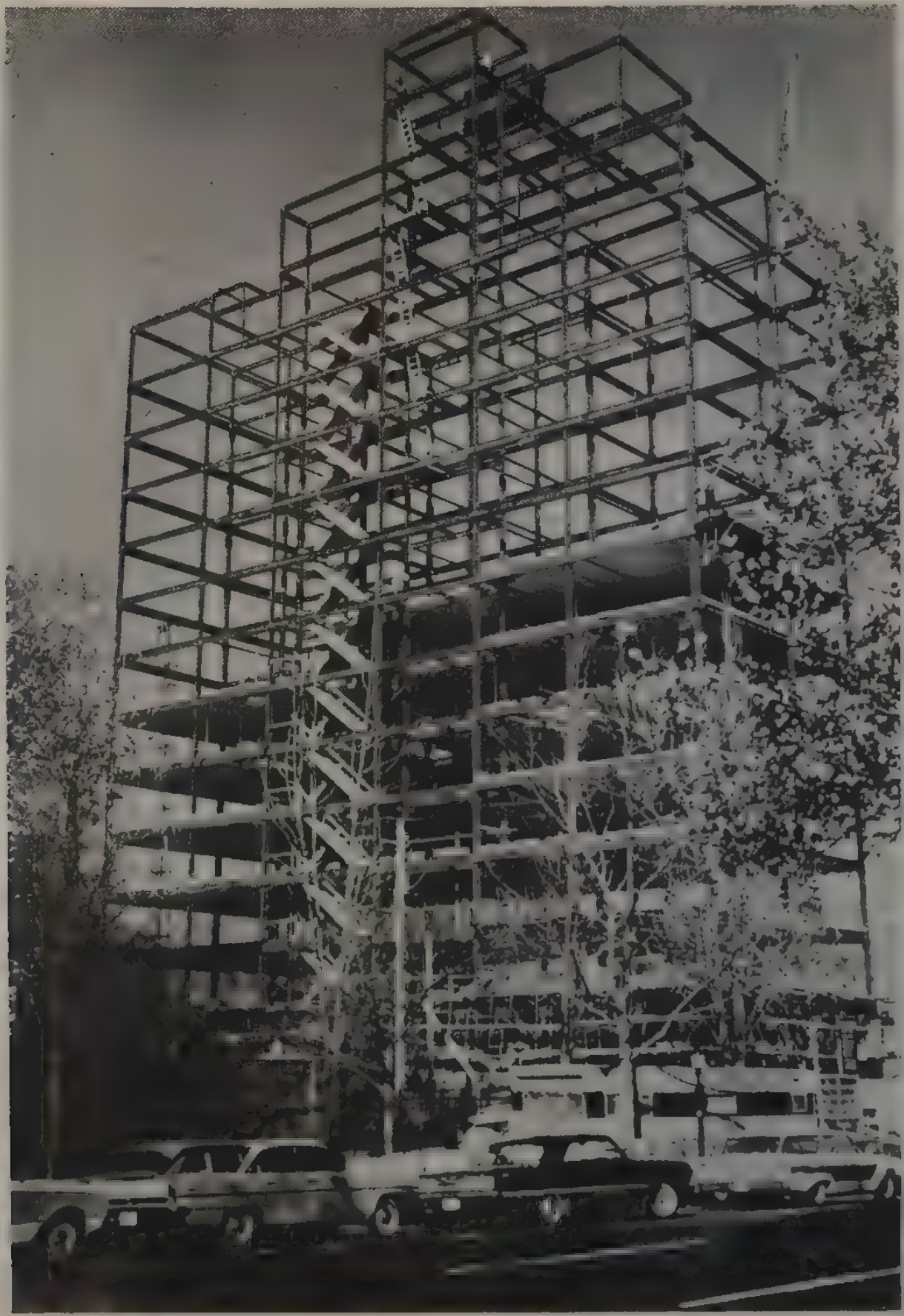
These units are manufactured in a rigid steel form made sufficiently strong to resist the pretensioning force applied by the seven wire strand reinforcing steel. Specially constructed rubber tubes are inflated to form circular voids so as to constitute approximately 50% of the cross section. The concrete is thoroughly vibrated to assure maximum denseness and strength.

The slabs may be cast of concrete made of gravel, crushed stone or lightweight aggregate. When lightweight aggregate is used, the unit weight is approximately 25% less. They are cured in a heated kiln.

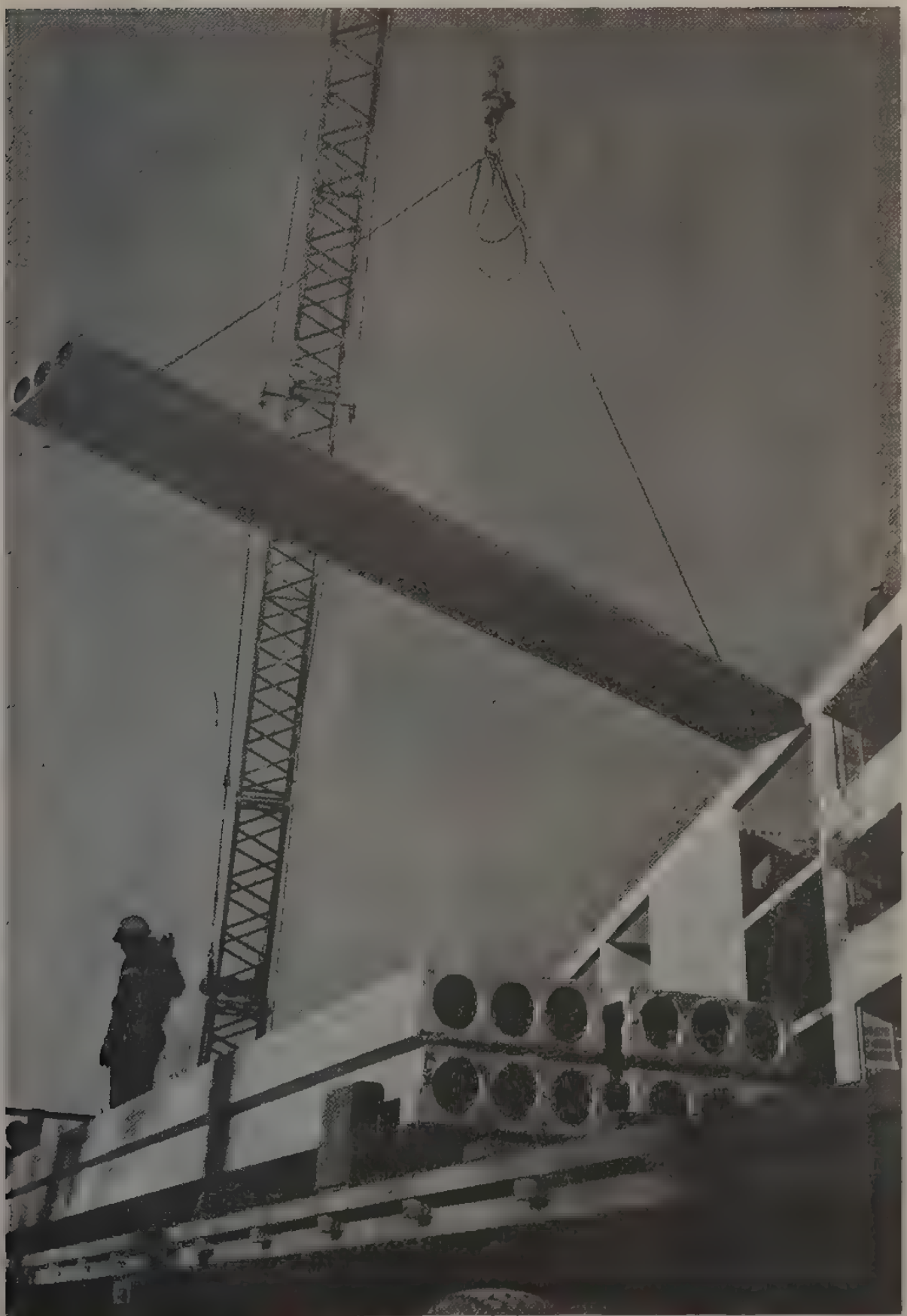
Erection.—Flexicore units are usually delivered to the job by truck. They are hoisted from the truck to the floor location and often placed directly into their final position by the crane. For more remote areas, they can be moved by a pair of rubber tired erection carts. After the slabs are placed side by side, they are aligned and levelled by driving wedges into hoops cast in adjacent slabs. The keyways in the sides of the slab are then filled with a grout mixed in a ratio of one to three. The wedges remain in place until the cement grout hardens. The erection crew usually consists of five men, including a crane operator, a foreman and three laborers. A crew will unload, erect and grout 2000 sq. ft. per day on smaller jobs to approximately 5000 sq. ft. on some larger jobs.

Since all the Flexicore plants are not equipped to make all the sections listed in Table I, the availability for each section and available length should be checked locally.

*Trademark of The Flexicore Co. Inc.



Flexicore on Lightweight Steel Frame.



Flexicore Slabs Erected Directly from Truck.

Cost of Flexicore Floor Slabs.—Flexicore slabs are usually quoted on an erected basis by the manufacturer and the price will usually include the cost of grouting, and caulking of the joints on the ceiling side. The price will vary according to the type of building, size, live load, span, section specified, location, etc. but usually runs from $1.25 to $2.00 per sq. ft. erected, grouted and caulked.

In localities distant from the manufacturing plant, the slabs are often sold on an f.o.b. basis and erection is performed by the contractor using his own men.

Caulking of the joints on the underneath is undertaken after the building has been enclosed. A non-staining type caulking material is used and will average about 5 cents per lineal foot. An underlayment which is not included in the bid is generally used over the Flexicore slabs and is provided by the general contractor.

PRESTRESSED CONCRETE

Within a relatively short period of time prestressed concrete has taken a very significant place in the building industry in North America. Firms producing prestressed concrete structural members number about 320 and are located in every part of the United States and Canada.

The use of prestressed concrete began in Europe some 40 years ago. A French engineer, Eugene Freyssinet, is generally regarded as the developer of the prestressing concept. Many spectacular prestressed concrete structures have been designed by Mr. Freyssinet and others in Europe and in Latin America and more recently in this country. The first major application of the use of prestressed concrete in the United States was the Walnut Lane Bridge in Philadelphia, Pa. This structure was completed in 1950 and since that time thousands of bridges and buildings have been constructed with structural elements of prestressed concrete.

Prestressed concrete was developed partly out of necessity as scarcity and the consequent high price of conventional building materials was experienced in Europe during and after the war years. The concept of utilizing the available materials to their fullest capacities was experimented with until techniques were perfected which developed prestressing into a workable and practical method of construction.

The American Concrete Institute defines prestressed concrete as "concrete whose stresses resulting from external loadings are counterbalanced by prestressing reinforcement placed in the structure." This is accomplished by precompressing the concrete by means of internal high tensile strands stressed a predetermined

Walnut Lane Bridge, Philadelphia, Pa. The First Major Use of Prestressed Concrete Structural Members in the Western Hemisphere

amount. This prestressing introduces compressive stresses into the concrete which counteract the stresses induced when the external loading is applied. The high strength strands are restrained in the member by either bond between the concrete and the strands,

or by end bearing devices. These two basic methods of restraining the strands are known as "pretensioning" and "post-tensioning."

In pretensioning, the strands are tensioned prior to casting the concrete and in post-tensioning the strands are tensioned after the concrete is cast. In general, the post-tensioning process is accomplished at the job site when casting large members. The member is cast with the strands properly positioned in the form and, after the concrete has reached sufficient strength, the tensioning members are stressed and secured by means of end bearing devices.

The pretensioning methods are particularly adaptable to the mass production of building elements such as double and single tees, channel sections, I joists and beams, T joists, hollow slabs and flat planks, among others. These members are usually cast in steel casting beds from 100 ft. to 600 ft. long. With the use of high quality concrete, low slumps and steam curing, a complete manufacturing cycle may be accomplished in a day.

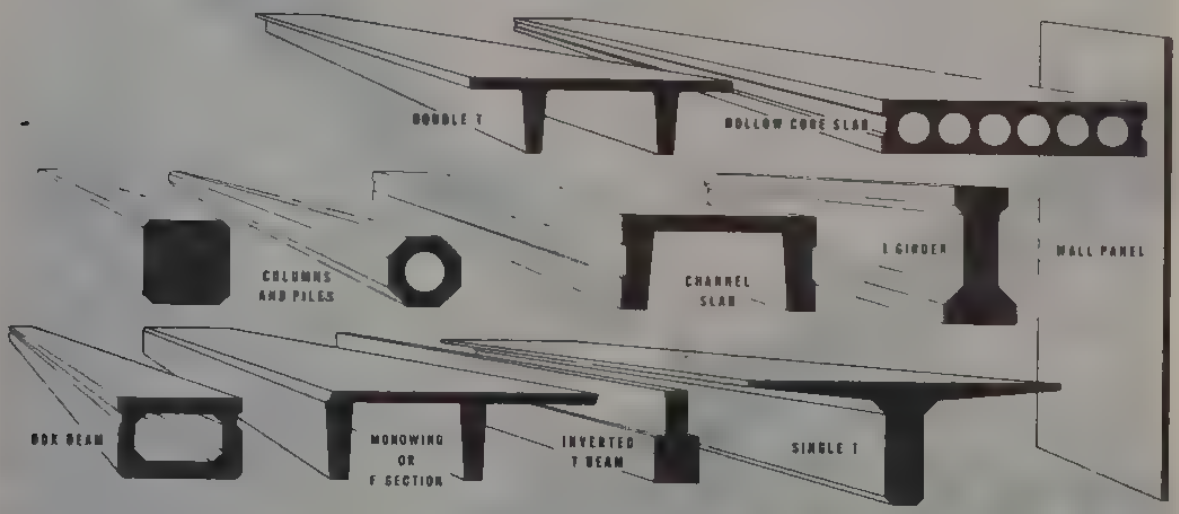
The prestressed and precast industry is based upon the economics of prefabrication and maximum use of the casting facilities. The larger the project and the number of units of identical span and section, the lower the unit cost.

Building Elements of Prestressed Concrete.—Precast / Schokbeton Inc. of Kalamazoo, Michigan has a modern prestressing

Modern Prestressing Plant

plant for the manufacture of prestressed concrete building elements. The plant is equipped with a variety of casting beds capable of producing a full range of prestressed products, including both structural and architectural components.

Included in the structural items available in the United States are single and double tee slabs, "F" or Monowing slabs, channel slabs, and Flextee slabs for floor and roof construction. Columns, beams and girders are available in a wide range of sizes and shapes.



Typical Prestressed Concrete Products

Architectural products made at the Precast/Schokbeton plant include precast concrete stadium seats, miscellaneous free form concrete made to order, and Schokbeton products produced under a license from N. V. Schokbeton of Zeist, Holland. These include wall panels, window facades and frames, column shells, stair treads, etc.

Cost of Prestressed Concrete Structural Elements.—As prestressed concrete building elements are now manufactured generally throughout the country, prices may usually be obtained from local sources. As stated previously, casting beds are in most cases long enough to cast any length member desired: length, width, height and weight must be acceptable to local trucking regulations.

There are, of course, many variables which can influence the cost of the installed product, such as the size of the job; the number of identical units in a job; the distance from the plant to the job site; the length of the units, as extremely long units will probably require special handling at the plant, in transit and at the job site; accessibility at the site; the size and number of cranes or other

Erection of Double Tee at O'Hare Field Terminal Building, Chicago, Ill.

Erection of Roof Slabs

equipment required for erection; the condition at the ground, etc. Costs given below are average for the Chicago area, which is a relatively high cost area. In some other areas of the country costs will be less.

The cost of a roof system in a one or two story building with the most economical slab spans which are from 40 to 60 ft. would probably fall in the range of $1.50 to $1.80 per sq. ft. erected under average conditions.

The cost of a floor system for a 100 lb. per sq. ft. live load or the most economical slab spans which are from 25 to 40 ft. would probably fall in the range of $1.70 to $2.00 per sq ft. erected under average conditions.

For a complete structure which would include columns, girders and roof slabs, with roof slabs spanning 50 to 60 ft. and girders spanning about 30 ft., the costs would probably fall in the range of $2.25 to $3.00 per sq. ft.

A two story building complete with columns, girders, floor and roof with identical spans and a nominal number of openings, etc. would probably cost a minimum of $3.00 per sq. ft. of framed floor

and roof, and a more complicated building might run as much as 50 cents to $1.00 more.

Erection of Prestressed Concrete Building Units.—If prestressed concrete building units are purchased from a manufacturer for erection by the general contractor or another subcontractor, the cost of erection will be influenced by the same factors as stated above. For an average job under normal conditions the cost of erection might run from 15 to 40 cents per sq. ft., depending upon product, size, etc.

A typical erection setup for an average job would include a crane, crane operator, oiler, five iron workers, welding machines and other miscellaneous equipment and tools. With move-in and move-out time for the cranes, dead time due to the weather or breakdowns, contingencies, etc., the daily cost of an erection setup such as this will average about $1,000 per day. On a large job and under good conditions an experienced crew can probably erect

Erection of Single Tee Roof Slabs.

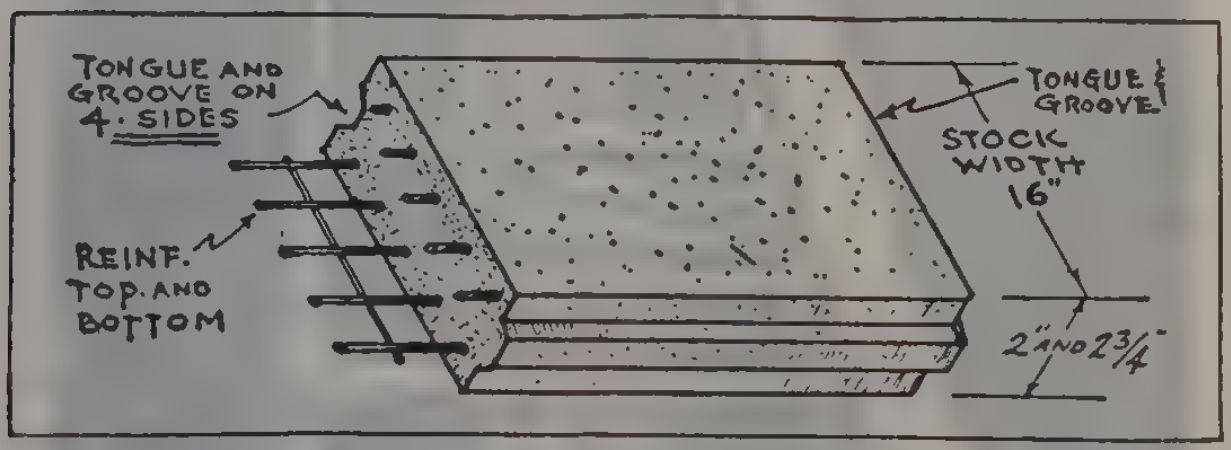
6,000 to 10,000 sq. ft. or more per day. On smaller jobs or where working conditions are below average, a crew might only erect 3,000 to 4,000 sq. ft. per day.

The Prestressed Concrete Institute, with offices in Chicago, Illinois, is a source of the latest reference material on prestressed concrete and can provide assistance to the design profession as well as to the purchaser of prestressed concrete products.

CONCRETE PLANK

Cantilite* is a lightweight high-strength concrete plank that is nailable and easily cut in the field. In laying, it is clipped to steel or wood beams. Floor or roof materials are nailed to it. Planks are factory-made in steel forms to give a smooth, even surface on all sides and to assure proper positioning of the reinforcing steel. Side edges are tongued and grooved.

Concrete plank are used for floors and roofs. The plank are



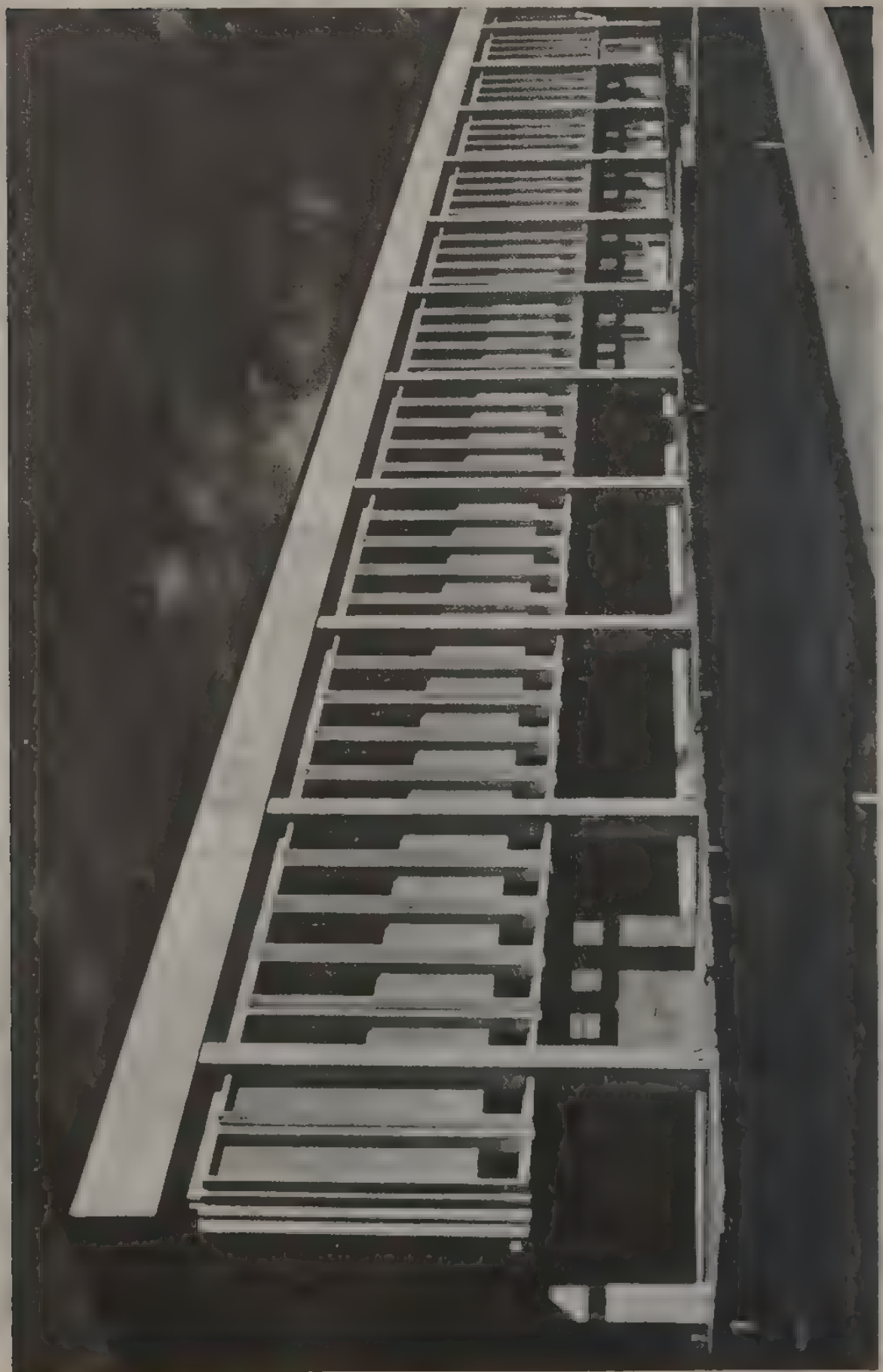
2" and 2¾" thick, 16" wide and made in lengths up to 10'-0". The 2" plank are used on steel or concrete joists, 4'-0" on centers for floors. The 2¾" plank are placed on steel or concrete joists up to 5'-0" on centers for floors. A 1" or 2" cement finish top is placed over the plank. Roofs having a span up to 7'-0" will require 2" plank, while 2¾" plank will be required for a roof span up to 8'-0".

Concrete plank cost 47 to 60 cts. per sq. ft., f.o.b. factory, depending upon quantity in the job. The 2" plank weigh 13 lbs. per sq. ft.; the 2¾ plank, 18 lbs. per sq. ft.

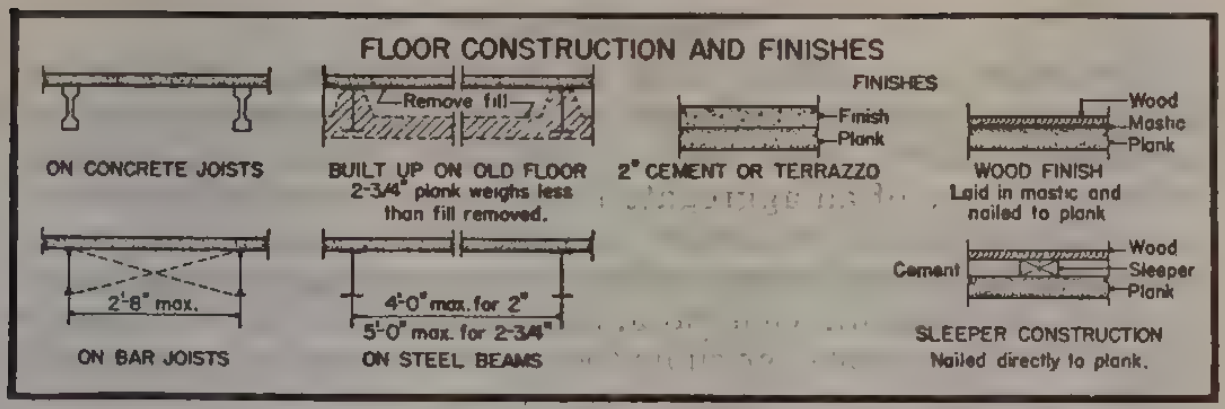
Labor Erecting Concrete Plank.—A crew consisting of 2 bricklayers and 4 laborers can handle and lay approximately 2,000 sq. ft. of plank per 8-hr. day, on a flat surface.

On a large job (80,000 to 300,000 sq. ft.) where it is possible to

* Concrete Plank Co., Inc., North Arlington, N. J.



Example of Architectural Concrete



work two erection crews, and use a hoist to hoist all materials, it is often possible for each crew to handle and lay 4,000 to 5,000 sq. ft. of plank per 8-hr. day, on flat surfaces.

Cost of 100 Sq. Ft. of Concrete Plank Laid on a Flat Floor or Roof Surface.

Cost does not include cement finish top over concrete plank.

	Hours	Rate	Total	Rate	Total
105 sq. ft. concrete plank		$.....	$.....	$0.50	$52.50*
Freight and cartage		.....	.....	.04	4.20*
Mason	0.8	.....	.....	6.50	5.20
Labor	1.6	.....	.....	5.00	8.00
Hoisting engineer**	0.2	.....	.....	6.00	1.20
Cost per 100 sq. ft.	2.6		$.....		$71.10
Cost per sq. ft.					.711

**Use only if required. *Varies according to locality.

POREX* PLANK

Porex is a mineralized wood fiber plank that is bound under pressure and manufactured with a factory-applied nailable cement surface, which serves as a positive nailing base for application of shingles or built-up roofing. It is manufactured in various thicknesses and will provide a high insulating value and excellent acoustical properties when left exposed. The thicknesses, spans, insulation value, and costs are listed below.

Thickness	Span	Insulation Value	Cost Per Square Foot
2"	3'-0"	.20	$0.50
2½"	3'-6"	.17	.55
3"	4'-0"	.15	.60

The above costs are approximate values for installation of material on projects with roof areas over 10,000 square feet. The material is manufactured with a white prime coat on its underside, which will serve as a base coat for field painting if the material is to be left exposed.

*Concrete Plank Co. Inc., North Arlington, N. J.

PORETHERM*

Poretherm is a cellular concrete that is manufactured on the job site with specially designed equipment. The material contains portland cement, water, and a stabilized foam, and is mixed without the use of an aggregate in order to achieve a low density material with good insulation properties. It is applied on top of corrugated steel decks and reinforced concrete to serve as insulation and drainage fill. General applications of the material require a density of 30 pounds per cubic foot with an ultimate compression of 200 psi and an insulation value k factor .70.

Approximate costs, based on quantities, are as follows:

30— 75 cubic yards	$60.00 per cu. yd.
75—100 cubic yards	$50.00 per cu. yd.
100 –200 cubic yards	$40.00 per cu. yd.
Over 200 cubic yards	$35.00 per cu. yd.

The above costs vary with local labor conditions but are approximate for installations on the eastern seaboard.

PRECAST CONCRETE ROOF SLABS

Precast concrete roof slabs are of three general types: Rib, Flat and Channel. They are adapted to all roof decks, flat or sloping, are fireproof and with caulked joints, present a smooth surface for the application of built-up roofing. Where slate, ornamental tile or copper covering is specified, slabs with nailing surfaces can be furnished, permitting direct application.

Precast concrete roof slabs are furnished made with regular concrete aggregates or where a lightweight slab is desired, they are made of lightweight (Haydite) aggregate.

The rib tile is self-weathering and its attractive red color provides an architectural feature that is very desirable and so often lacking in industrial buildings. Auxiliary pieces are furnished to suit the particular design required, as ridges, sawtooth ridges, gable end finishing tile, monitor flashing tile and other specials such as would be required in connection with a hip or valley.

Tile of the same standard stock sizes, but having a glass insert, may also be furnished where additional light may be required. On this type of roof slab it is necessary to obtain prices from the manufacturer due to the fact that the amount of trim varies with each project.

The other two types of precast concrete roof slabs, Flat and

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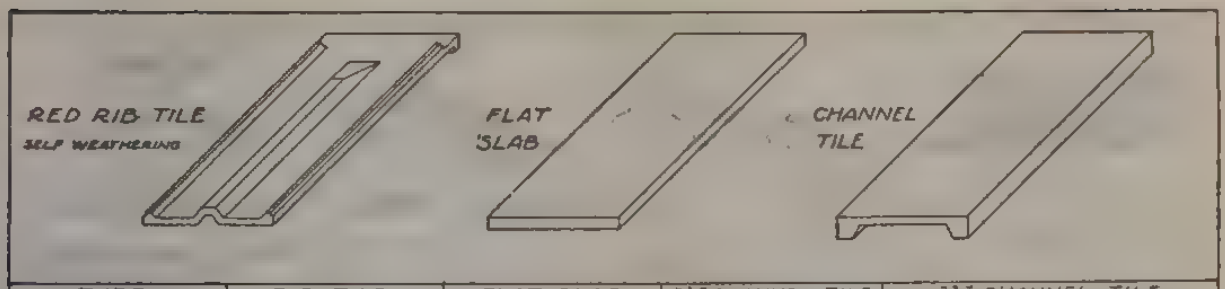
*Concrete Plank Co. Inc. North Arlington, N. J.



TYPE	RIB TILE	FLAT SLAB	2¾" CHANNEL TILE	3¾" CHANNEL TILE
WIDTH	24" } STOCK SIZE	24" } STOCK SIZE	24"	24" | 18"
LENGTH	4'-4" } STOCK SIZE	5'-0" } STOCK SIZE	6'-6" MAX.	6'-0" MAX | 5'-0" MAX
THICKNESS	WEB-1⅛"	1⅝"	LEG-2¾" - WEB-1"	LEG-3¾" - WEB-1"
WEIGHT PER SQ. FT. HAYDITE	16 LBS.	13.5 LBS.	10.5 LBS.	12 LBS. | 13.5 LBS.
WEIGHT PER SQ. FT. SAND	17 LBS.	19 LBS.	16 LBS.	17.5 LBS. | 19 LBS.
REINFORCEMENT	WELDED GALV. MESH	WELDED GALV. MESH	MESH & 2 DEF. BARS	MESH & 2 DEF. BARS
ROOF PITCH	½ PITCH OR GREATER	FLAT OR PITCHED	FLAT OR PITCHED	FLAT OR PITCHED
ROOFING	SELF WEATHERING	COMP. ROOFING REQ'D	COMP. ROOFING REQ'D	COMP. ROOFING REQ'D
PURLIN SPACING	4'-0½" MAX. - 3'-9" MIN	5'-0" MAX	6'-6" MAX	6'-0" MAX | 5'-0" MAX.

Sizes and Weights of Precast Concrete Roof Tile

Channel, are used over all roof decks, whether flat or sloping, and present a smooth surface for the application of any type of built-up roofing. When used with a sloping roof and when slate or other types of ornamental covering are to be used, these slabs can have a concrete nailing surface superimposed and manufactured integrally with the structural slab.

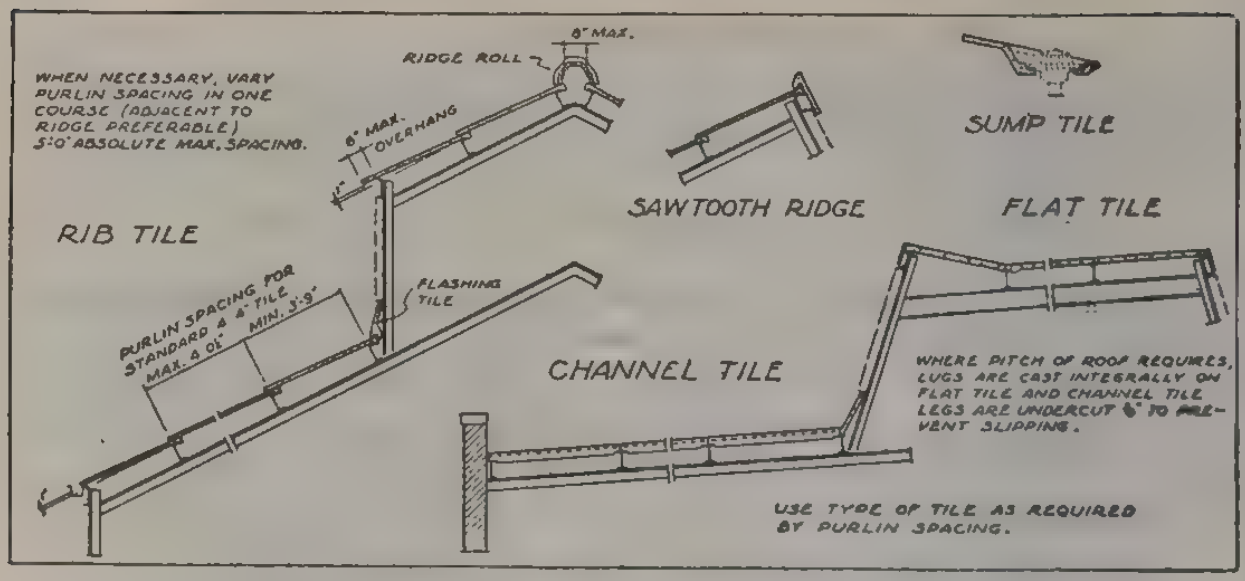
The accompanying illustration gives the sizes and weights of the various types of tile.

Approximate Prices of Precast Concrete Roof Slabs.—The following prices are f.o.b. manufacturer's warehouse, to which it will be necessary to add freight to destination, plus approximately 1-ct. per sq. ft. for caulking compound used to caulk the joints.

Kind of Tile	Price per Sq. Ft.
Flat Slab Tile, 1⅝" thick, haydite concrete	$0.51—$0.53
Flat Slab Tile with nailing concrete 1¼" top	.85— .90
2¾-in. Channel Tile, haydite concrete	.42— .45
2¾-in. Channel Tile with nailing concrete top	.80— .85
3¾-in Channel Tile, haydite concrete	.45— .47

Labor Placing Precast Concrete Roof or Floor Slabs.—Because of their size and weight it requires 2 men to handle precast concrete roof or floor slabs, as each piece weighs from 125 to 200 lbs. Ordinarily it requires 2 men on the ground handling the slabs and getting them to the hoist and two men on the floor or roof placing them for the mason, and a mason and helper to lay and caulk the joints.

A mason and helper should lay and caulk 960 to 1,050 sq. ft. of haydite concrete tile per 8-hr. day on straight roofs.


WHEN NECESSARY, VARY PURLIN SPACING IN ONE COURSE (ADJACENT TO RIDGE PREFERABLE) 5'-0" ABSOLUTE MAX. SPACING.
RIDGE ROLL
6" MAX.
6" MAX. OVERHANG
SAWTOOTH RIDGE
SUMP TILE
FLAT TILE
RIB TILE
PURLIN SPACING FOR STANDARD 4 4" TILE MAX. 4'-0" MIN. 3'-9"
FLASHING TILE
CHANNEL TILE
WHERE PITCH OF ROOF REQUIRES, LUGS ARE CAST INTEGRALLY ON FLAT TILE AND CHANNEL TILE LEGS ARE UNDERCUT 6° TO PREVENT SLIPPING.
USE TYPE OF TILE AS REQUIRED BY PURLIN SPACING.

Details of Precast Concrete Roof Tile Construction

Cost of 100 Sq. Ft. of Precast Haydite Concrete Channel Tile on Straight Roofs

	Hours	Rate	Total	Rate	Total
100 sq. ft. haydite tile....		$.....	$.....	$0.45	$45.00*
¼-gal. caulking compound		.....	.....	5.00	1.25
Freight and cartage.....		.....	.....	3.50	3.50**
Mason	0.8	.....	.....	6.50	5.20
Helper	0.8	.....	.....	5.00	4.00
Labor	2.0	.....	.....	5.00	10.00
Cost per 100 sq. ft.....	3.6		$.....		$68.95
Cost per sq. ft.....			.....		.69

Add for hoisting engineer, if required.

For nailing concrete slabs, add 33 to 35 cts. per sq. ft.

USG† METAL EDGE GYPSUM PLANK

A lightweight, incombustible construction for roofs and floors in connection with steel framing.

USG† Metal Edge Gypsum Plank are made in 2"x15"x10'-0" units and designed for roofs on spans up to 7'-0". The plank is available in two types: MEP-4 for spans up to 4' and MEP-7 for spans up to 7'.

All plank are molded and have steel tongue and groove edging on sides and ends, firmly anchored into the gypsum. They also have an electrically welded galvanized steel fabric as reinforcement for the gypsum. Weight 10.5 lbs. per sq. ft.

On jobs requiring approximately 3,000 sq. ft. or more, the

*Varies according to kind of tile used.
**Freight and cartage varies according to location.
†United States Gypsum Co.

plank cost about 34 cts. per sq. ft. in the eastern zone of the United States.

Labor Laying Metal Edge Gypsum Plank.—One plank (12½ sq. ft. in area) will weigh 133 lbs. requiring 2 men to handle a single plank. Ordinarily it will require 2 men on the ground, 2 men on the roof and 1 tile setter laying. This crew should lay approximately 1,200 sq. ft. per 8-hr. day.

Cost of 100 Sq. Ft. of Metal Edge MEP-7 Gypsum Plank on Roofs

	Hours	Rate	Total	Rate	Total
102½ sq. ft. gypsum plank.		$.....	$.....	$ .34	$34.85
Freight on 1.26 CWT		.....	.....	.035	4.41
Tile setter.....	0.7	.....	.....	6.20	4.34
Labor.....	2.7	.....	.....	5.00	13.50
Cost per 100 sq. ft.....	3.4		.....		$57.10
Cost per sq. ft.....			.....		.57

MEP-4 Plank costs 30 cts. per sq. ft. for material and about 49 cts. per sq. ft. installed.

The above costs contemplate ordinary flat slab work, on a job containing 3,000 to 4,000 sq. ft., with a minimum amount of cutting. Labor costs may be halved on efficiently handled jobs of 20,000 sq. ft. or over. Add for extra handling and cutting for pitched roof and double the above labor costs for pitched roofs having hips, valleys, dormers, etc. Add extra for hoisting engineer if required.

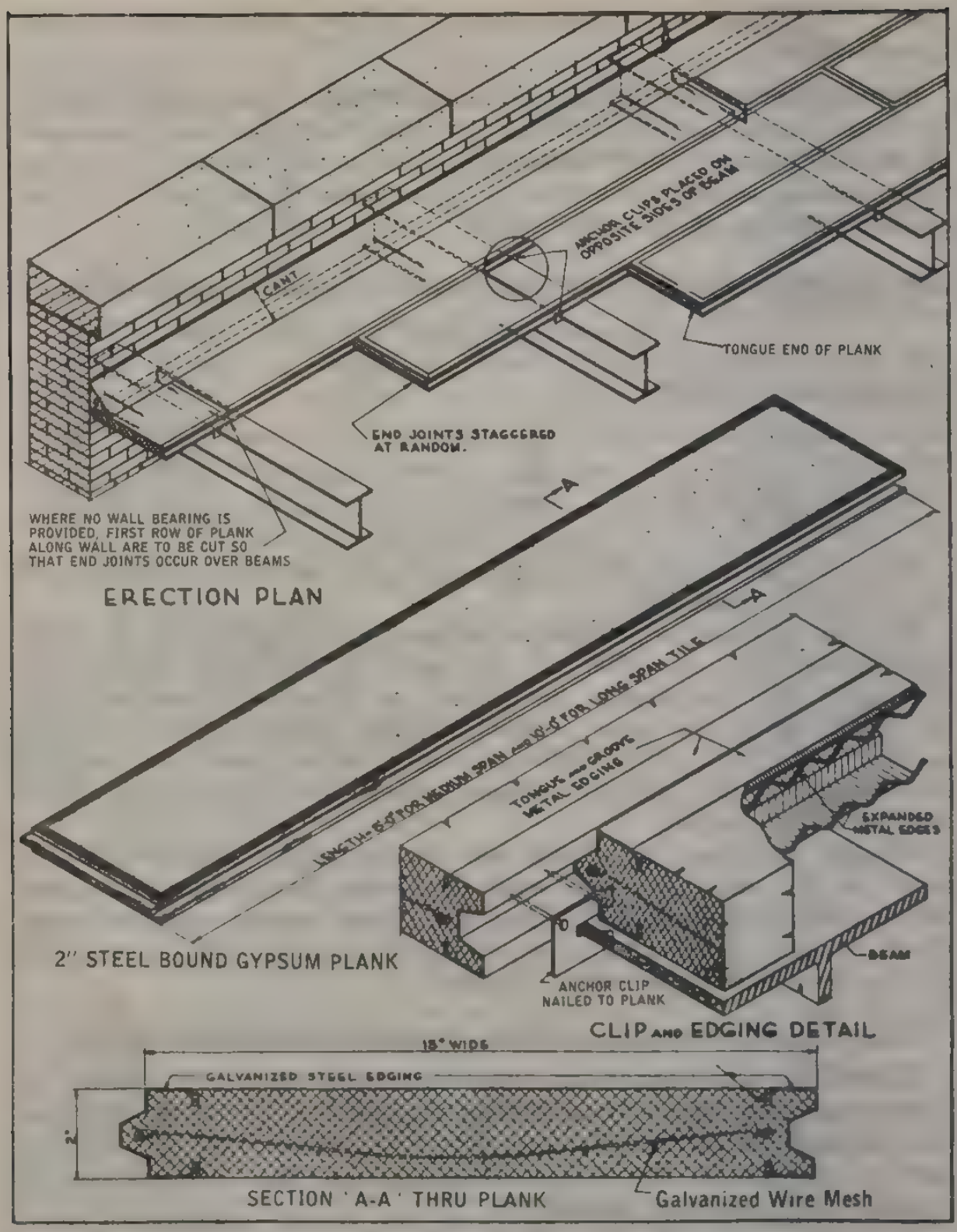
A water resistant core plank has been developed by USG.* It is made in the same size and with the same details as the regular metal edge gypsum plank. The cost of the water resistant core plank is approximately 37 cts. per square foot. Erection costs will be the same as for the regular plank.

Monolithic or Poured-in-Place Gypsum Roof Construction

Monolithic or poured in place gypsum roof deck, with its continuous reinforcing and securely welded sub-purlins, becomes an integral part of the main steel construction of a building, adding rigidity to the entire structure and can be designed for any required loading condition.

Permanent form boards which remain as the undersurface of the completed deck may be ½" gypsum form board; ¾" or 1" wood fiber insulation form board; ¼" asbestos cement board; 1" wood fiber insulation acoustical form board, 1" mineral fiber form board, and ½" plastic faced gypsum formboard.

*United States Gypsum Co.


ANCHOR CLIPS PLACED ON OPPOSITE SIDES OF BEAM
CANT
TONGUE END OF PLANK
END JOINTS STAGGERED AT RANDOM.
WHERE NO WALL BEARING IS PROVIDED, FIRST ROW OF PLANK ALONG WALL ARE TO BE CUT SO THAT END JOINTS OCCUR OVER BEAMS
ERECTION PLAN
A
A
LENGTH - 6'-0" FOR MEDIUM SPAN AND 10'-0" FOR LONG SPAN TILE
TONGUE AND GROOVE METAL EDGING
EXPANDED METAL EDGES
2" STEEL BOUND GYPSUM PLANK
BEAM
ANCHOR CLIP NAILED TO PLANK
CLIP AND EDGING DETAIL
18" WIDE
GALVANIZED STEEL EDGING
2"
SECTION 'A-A' THRU PLANK
Galvanized Wire Mesh

Details of U SG Metal Edge Gypsum Plank

Rolled steel sections designed to carry all loads between supports shall be laid on the top of walls, beams or roof supports at sufficient spacing to receive the form boards on the lower flanges; "reinforcing shall be 48-1214 galvanized welded wire fabric hav-

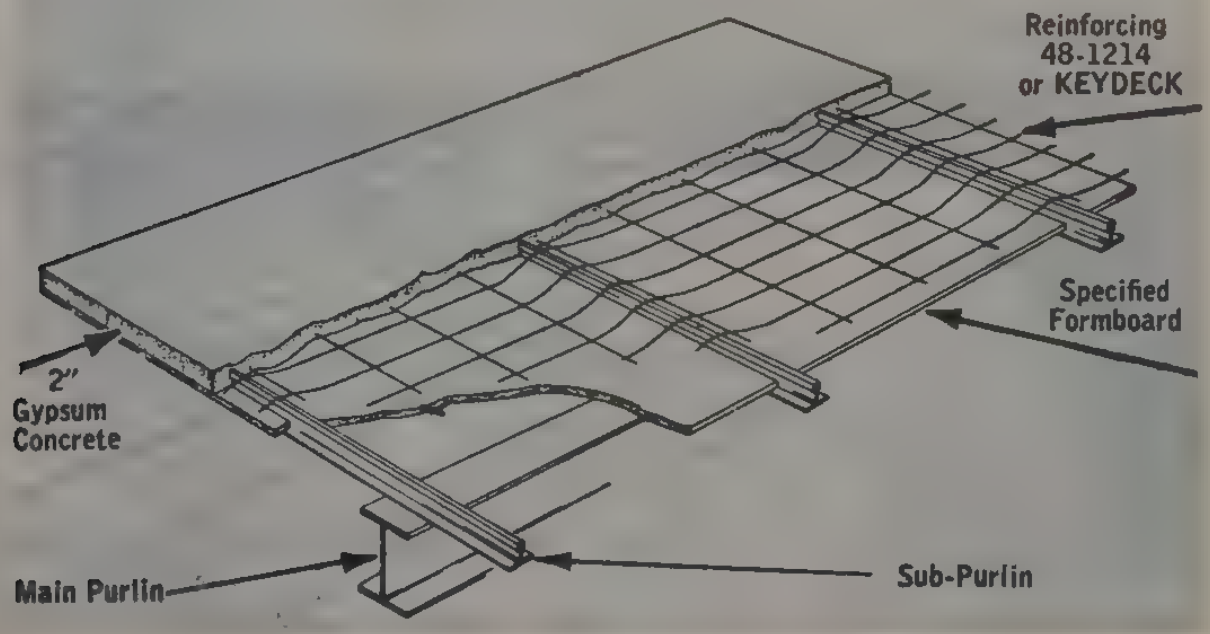
ing 12 ga. longitudinal wire spaced 4" on centers and 14 ga. transverse wired 8" on centers or "Keydeck," a galvanized woven mesh as manufactured by Keystone Steel and Wire Co., having 16 ga. longitudinal wires and 19 ga. diagonal wires. The effective cross sectional area of reinforcing shall be not less than 0.026 sq. in. per ft. of slab width."

Standard (mill mixed) gypsum composition containing at least 87½ percent calcined gypsum is mixed with water to a medium quaking consistency and poured or pumped in place, forming a solid reinforced slab 1½" or 2" thick (or more, if desired), plus the board undersurface. The top surface of the slab shall be screeded smooth and left ready to receive the specified roofing.

The density of poured gypsum concrete is approximately 50 lbs. per cu. ft. When cast in the minimum thickness of 2", the total dead weight of the slab is about 10 lbs. per sq. ft.

The weights (excluding sub purlins) and insulating values of poured gypsum roof decks are as follows:

Description	Weight per Sq. Ft.	"U" Value BTU.
2" gypsum concrete on ½" gypsum form boards or plastic faced board	11.0 lbs.	.37
2" gypsum concrete on 1" fiber insulation form board	10.0 lbs.	.20
2½" gypsum concrete on ¼" asbestos cement board	11.0 lbs.	.40
2" gypsum concrete on 1" mineral fiber form board	10.0 lbs.	.17



Poured Gypsum Roof Deck Construction

Asbestos cement form boards should be used for poured gypsum roof installations in buildings where heat or humidity is higher than normal and on exterior overhangs.

Acoustical roof decks consist of a 2″ thick reinforced gypsum concrete slab poured in place over especially made acoustical form board to provide a rigid, monolithic insulated roof deck with high sound absorption, as well as acoustical correction. Sub-purlins are usually spaced 24⅝″ o.c. to accommodate 24″ wide acoustical form board.

The accompanying illustration shows the type of roof construction that is widely used for schools, auditoriums, field houses, gymnasiums, factory, industrial and many commercial buildings, in fact, for most any steel skeleton structure where a permanent, incombustible, highly insulated roof is desired.

Practically all gypsum concrete is now mixed mechanically and pumped from ground to roof level as a means of further increasing the speed of operation and uniformity of quality, with corresponding reduction in cost.

The cost of poured-in-place gypsum roof decks will vary with the size and type of structure, availability of materials, freight charges, labor rates, etc., but the simplicity of design, lightweight

Method of Pouring Gypsum Roof Decks

and speed of erection, incombustibility and finished undersurface make the overall cost of this construction very economical.

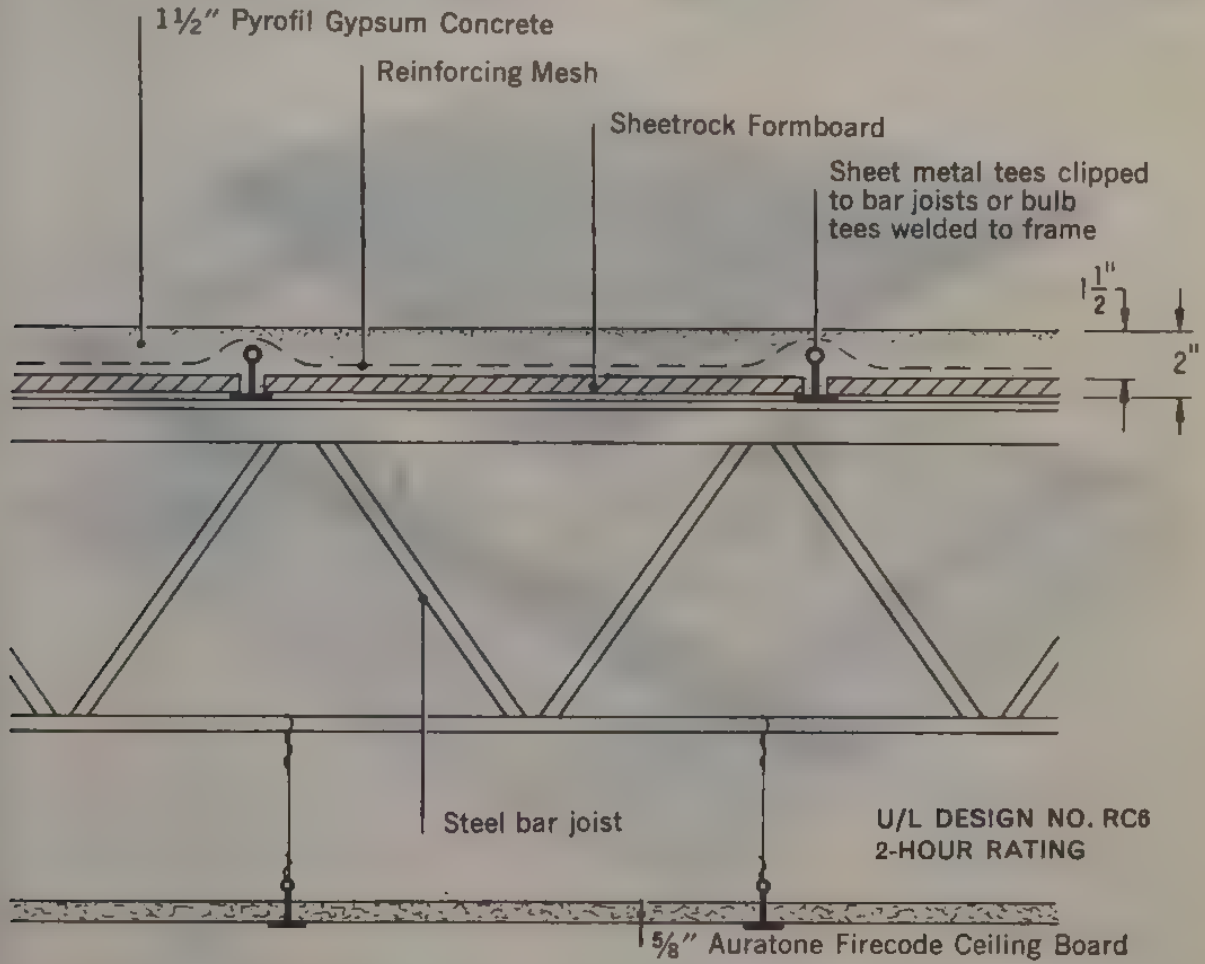
Poured-in-place gypsum roof decks are applied by contractors approved by the manufacturers of the materials.

The following are approximate prices only on the various types of poured-in-place gypsum roof decks. These prices may vary locally due to labor and material costs, freight rates or size of specific job.

For definite prices on any project it is always advisable to consult a roof deck contractor specializing in this type of construction.

Approximate Sq. Ft. Prices on Poured Gypsum Roof Decks

Type of Roof	Approximate Price Range per Sq. Ft.
2″ gypsum concrete on ½″ gypsum form boards..	$0.38—$0.43
2″ gypsum concrete on 1″ insulation form boards	0.44— 0.50
2″ gypsum concrete on ¼″ asbestos cement board.	0.45— 0.50



Courtesy of U. S. Gypsum Co.

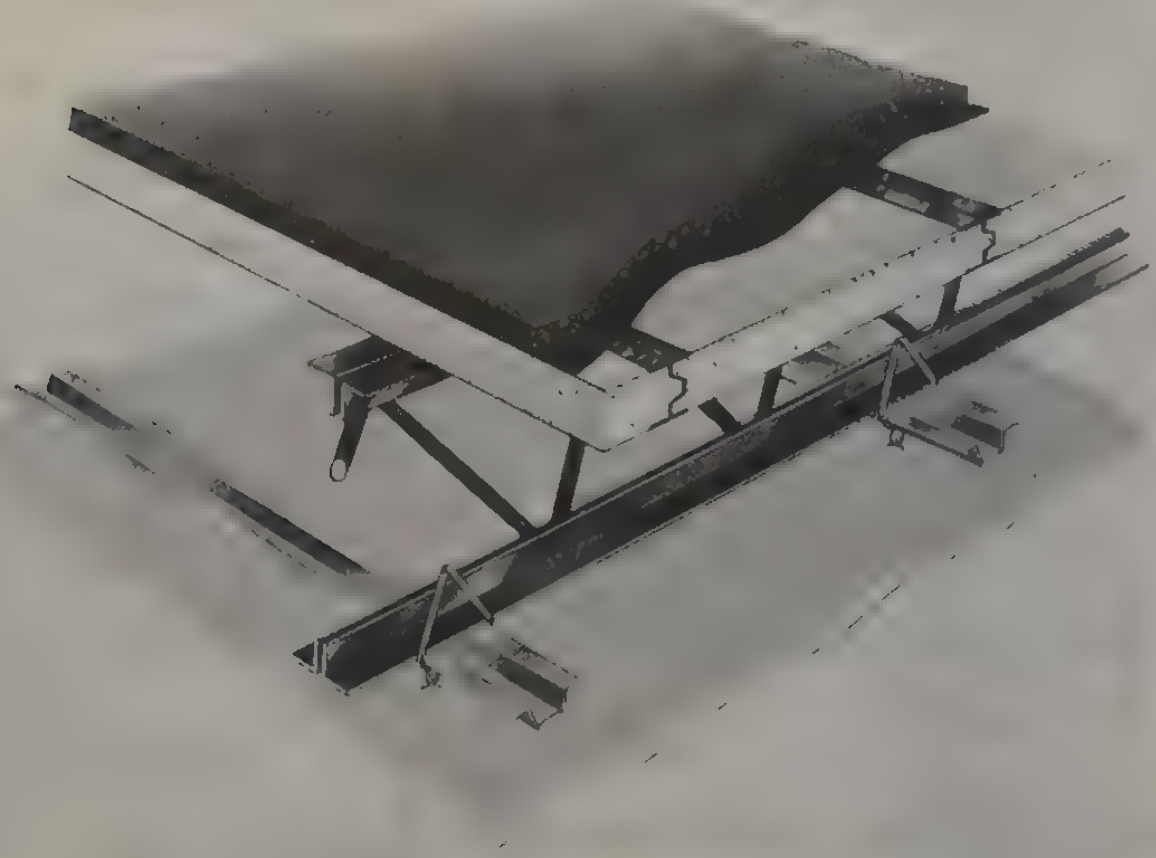
Two Hour Fire Rated Roof and Ceiling Assembly

Type of Roof	Approximate Price Range per Sq. Ft.
2″ gypsum concrete on 1″ acoustical form board..	0.55— 0.70
2″ gypsum concrete on 1″ mineral fiber form board	0.45— 0.50
For each additional ½″ in thickness of gypsum concrete, add	0.03— 0.04

The accompanying illustration shows a poured gypsum roof on steel joists used in combination with acoustic ceiling boards of mineral fiber and lightweight perlite to comply with Underwriters' Laboratories design No. RC6 for a two hour fire rating. This assembly has a "U" value of 0.19, a noise reduction coefficient of .55 to .65, and a light reflectance of 85%. The approximate installed cost for deck and ceiling is $0.78 per sq. ft.

USG* Floor Plank Systems

USG Floor Plank Systems are lightweight incombustible assemblies for use with bar joists and floor loads of the magnitude generally found in apartment buildings and residence halls.



USG* Floor Plank System

*United States Gypsum Co.

USG* floor plank with tongue and grooved metal edges is laid dry without grout and welded to the joists. A topping of Mastical* underlayment and a ceiling of $\frac{5}{8}$" Sheetrock Firecode C* gypsum wallboard make up the complete floor system.

*United States Gypsum Co.

CHAPTER XI

INTEGRAL AND MEMBRANE WATER RESISTING COMPOUNDS, DAMPNESS RESISTING PAINTS, CONCRETE BONDING AGENTS AND CEMENT FLOOR HARDENERS

Nearly every building requires water and damp resisting material, plaster bonds or floor hardeners of one kind or another, and with the great number of preparations on the market, it is impossible for the best informed contractor or estimator to familiarize himself with even a small proportion of them.

No attempt has been made here to pass on the relative merits of the various preparations, but this data deals strictly with information that is of interest to the estimator, namely,—use of the material, covering capacity, and cost of applying same. The prices quoted are approximate, and may vary considerably in different locations. Always check with local distributors for current prices.

Water and Damp Resisting Methods.—There are several methods used by the different manufacturers for mixing and applying their products to produce a water resisting wall or surface. In some instances, the water repelling compounds are incorporated with the cement, sand, and gravel while the concrete is being mixed, and by filling the voids in the cement and sand produce a waterproof mixture. Where the various powders or pastes are mixed in the concrete mass it is called the integral method of waterproofing.

Some water and dampness resisting preparations are furnished in mastic form, and are applied with a trowel. Others are mixed with portland cement and sand and applied as a plaster coat to the surfaces to be treated.

There are also numerous water and dampness resisting compounds in the form of heavy paints, which are applied to the concrete or masonry walls, floors, and ceilings with a brush or mop. One or more applications of these materials are supposed to penetrate and fill the pores in the concrete or masonry surfaces to such an extent that the treated surfaces will be impervious to dampness or moisture.

Where there is considerable pressure or a large head of water, one of the most satisfactory methods is known as membrane waterproofing. This method consists of applying 2 to 7 hot moppings of pitch or asphalt on 1 to 7 plies of saturated felt or fabric. Waterproofing of this kind is applied in much the same manner as built-up roofing. After the last ply of saturated felt or fabric is applied the entire surface is mopped with a heavy application of hot pitch or asphalt.

Estimating Quantities of Water and Damp Resisting Preparations.—When estimating quantities of the various plaster coats, paints and membrane waterproofing compounds required for any job, the entire area of the walls or surfaces to be treated should be measured and the quantities stated in sq. ft., sq. yds. or by the square (100 sq. ft.).

Integral water resisting compounds are usually estimated by the cu. ft. or cu. yd. of concrete to which the liquid, paste or powder is added.

Water Required for Mixing Concrete.—When mixing concrete sufficient water should be used to produce a plastic mix—no more and no less. A plastic mix is concrete which can be readily molded and when the mold is removed will flow sluggishly without segregation of the water or the fine materials from the coarse. Concrete should be mixed at least 2 minutes after all materials have been placed into the mixer.

Remember there is nothing more injurious to good concrete than too much mixing water.

Refer to water required for mixing concrete as given under the "Water-Cement Ratio Method of Mixing Concrete," under Concrete Foundations.

WATERPROOFING BY THE INTEGRAL METHOD

When using the integral method, the admixtures are usually mixed with the cement and aggregate and form a part of the concrete mass. The quantities are based on the specifications of the various manufacturers.

Material prices given are approximate, as it is impossible to quote prices that will apply to every locality. Wherever possible the contractor or estimator should obtain local prices on the materials specified. Prices are based on material being purchased in drum or barrel quantities. When purchased in one gallon or one pound quantities the cost will be increased considerably.

Integral Liquid Admixtures

Integral liquid admixtures consist of (1) calcium chloride solu-

tions, (2) oil water repellent preparations and (3) other integral mixtures which flow freely from a drum.

The cost of hauling the barrel to the mixer, setting it up on blocks and drawing off the liquid by spigot into a measuring container will cost from 2½ to 3 cts. per gallon of waterproofing on small jobs. On large jobs this cost may be halved.

Concrete mixed in the proportions of 1:2:4 or 1:2½:3½ requires 5½ to 6 sacks of cement per cu. yd. of concrete.

Trade Name	Quan. per Sack Cement	Concrete Proportion	Quan. per Cu. Yd. Concrete	Approx. Price per Gallon
Anti-Hydro*†	1 qt.	1:2:4	1½ gal.	$1.70
Aquatite	⅔ qt.	1:2:4	1 gal.	.90
Aquatite*	1 qt.	1:2:4	1½ gal.	.90
Hydratite	1 qt.	1:2:4	1½ gal.	1.60
M. B. Pozzolith 100.	3 oz.	1:2:4	18 oz.	3.80
R.I.W. Toxement..	1 qt.	1:2:4	1½ gal.	1.00
Sikacrete	1 qt.	1:2:4	1½ gal.	.80
Trimix	1 qt.	1:2:4	1½ gal.	1.28

* Use where there is water pressure.
† A 5-year maintenance guarantee furnished by manufacturer where supervision is supplied at additional cost.

Powdered Integral Admixtures

This material should be added to the portland cement before the addition of aggregates and then dry mixed thoroughly before adding gauging water. Add about 1½ cts. per lb. to the cost of material for labor handling and mixing.

Trade Name	Quan. per Sack Cement	Concrete Proportion	Quan. per Cu. Yd. Concrete	Approx. Price per Lb.
Hydratite Powder ..	1 lb.	1:2:4	6 lbs.	$0.18
Hydrocide Powder .	1 lb.	1:2:4	6 lbs.	.19
M. B. Pozzolith* ...	¼ lb.	1:2:4	1½ lbs.	.60
Plastiment	½ to 1 lb.	1:2:4	3 to 6 lbs.	.26
R.I.W. Toxement ..	1½ lbs.	1:2:4	7½ lbs.	.20

*Dissolve 1 lb. in sufficient water to make 1-gal. solution.

WATER AND DAMP-RESISTING PLASTER COATS

There are numerous preparations on the market to be mixed with portland cement and sand and applied as a plaster coat

for waterproofing concrete and masonry walls. There are other preparations in mastic form that are applied with a trowel the same as ordinary cement mortar.

The materials described on the following pages include many of the better known preparations used for this purpose.

Estimating Quantities of Water or Damp-Resisting Plaster Coats.—Where water or damp-resisting plaster coats are applied to brick or concrete walls, the water resisting ingredient is usually in liquid, paste or powder form.

This compound is usually added to the mortar on the basis of a certain quantity to each sack of cement used and practically all manufacturers specify a mortar mixed in the proportions of 1 part portland cement to 2 parts sand, adding only sufficient water to make a workable mortar.

Quantity of Cement and Sand Required for One Cu. Yd. of Cement Mortar

Based on damp loose sand containing 5 percent of moisture and weighing 2,565 lbs. per cu. yd.

Proportions by Volume Cement Sand	Packed Cement Sacks	Loose Sand Cu. Yds.	Proportions by Volume Cement Sand	Packed Cement Sacks	Loose Sand Cu. Yds.
1 : 1	18.0	0.70	1 : 2½	11.0	1.03
1 : 1½	15.2	0.84	1 : 3	9.5	1.10
1 : 2	12.5	0.95			

Above quantities of sand include 5 percent for waste.

Number of Sq. Ft. of Cement Plaster Coat Obtainable from One Cu. Yd. of Cement Mortar

Thickness in Inches	Square Feet	Thickness in Inches	Square Feet
¼	1,296	¾	432
½	648	1	324

Cleaning and Washing Old Masonry or Concrete Surfaces.—Where old masonry or concrete surfaces are to be given a waterproof plaster coat, it will first be necessary to prepare the old surface to receive the cement plaster.

On some jobs it will be necessary to rake out the old brick joints to form a key for the plaster and on others it will be necessary to thoroughly wire brush the old surface to remove all surface dirt and then wash the surface with clean water or a solution of muriatic acid and water mixed in the proportion of 1 part acid to 10 parts water.

Where the surfaces are to be brushed and washed with

water or acid and water, the cost of cleaning 100 sq. ft. of surface should average as follows:

	Hours	Rate	Total	Rate	Total
1 qt. muriatic acid		$.....	$.....	$0.40	$ 0.40
Labor	2	.....	.....	5.00	10.00
Cost per 100 sq. ft.	2		$.....		$10.40
Cost per sq. ft.			.....		.104

Roughing and Hacking Old Concrete Walls and Other Vertical Surfaces.—Where it is necessary to roughen old, hard concrete surfaces to prepare a suitable bond for the new waterproof plaster coat, this can prove to be very expensive especially where the old concrete surfaces are very hard and must be hacked and roughened using hand tools, or a jackhammer or bush-hammering tool as the men are often obliged to work in cramped quarters, which prevents the best daily output.

On work of this kind, a man will roughen only 15 to 20 sq. ft. of surface an hr. at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Compressor expense	2.75	$.....	$.....	$4.00	$11.00
Compressor engineer*	2.75	.....	.....	6.00	16.50
Labor on jackhammer	5.50	.....	.....	5.25	28.88
Cost per 100 sq. ft.	8.25		$.....		$56.38
Cost per sq. ft.			.....		.564

*Add only if required.

Applying Slush or Grout Coat of Neat Cement.—After the old surfaces have been cleaned, it will be necessary to give them a slush coat of neat portland cement thoroughly brushed into the pores of the wall, which acts as a bond for the subsequent plaster coats.

The cost per 100 sq. ft. of surface should run as follows:

	Hours	Rate	Total	Rate	Total
1 sack cement		$.....	$.....	$1.80	$ 1.80
Labor	2	.....	.....	5.00	10.00
Cost per 100 sq. ft.	2		$.....		$11.80
Cost per sq. ft.			.....		.118

Labor Applying Waterproof Plaster Coats to Vertical Surfaces.—When applying waterproof plaster coats to vertical surfaces, the costs run high for the reasons, as listed below:

1. The costs arise in using slow setting waterproofings, stearates or oil waterproofings, in places that are difficult to work because of seepage and pumping.
2. Seepage requiring pumping.
3. Interference of other trades.
4. Difficulty of mixing and handling.
5. Delay in setting of coats.

6. Difficulty in finishing vertical surfaces of this type of plaster or cement finish.
7. Contingency cost of return to job for breaks and cracks.

This work is usually performed by cement masons or plasterers.

When applying waterproof plaster coats it is not necessary to give the surface a float or brush finish, but it must be reasonably smooth and without uneven projections that would prevent the water from running down the sides of the walls.

Most manufacturers specify the mortar to be mixed in the proportions of 1:1½ or 1:2, and the material is usually applied in one or two coats by a cement mason or plasterer.

A man should apply 250 to 300 sq. ft. of first coat per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Plasterer	3.0	$.....	$.....	$6.50	$19.50
Helper	3.0	.....	.....	5.10	15.30
Cost per 100 sq. ft.	6.0		$.....		$34.80
Cost per sq. ft.					.348

On the second or finish coat, a man should apply 175 to 225 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Plasterer	4.0	$.....	$.....	$6.50	$26.00
Helper	4.0	.....	.....	5.10	20.40
Cost per 100 sq. ft.	8.0		$.....		$46.40
Cost per sq. ft.					.464

If necessary to clean the old masonry or concrete surfaces with muriatic acid and water, or to roughen the old concrete, add for this work as given on previous page.

Cost of 100 Sq. Ft. Mastic Waterproof Coatings

The following materials are furnished in the form of a mastic or plastic cement and are applied with a trowel.

Kind of Waterproofing	Inches Thick	Number Coats	Cover Cap. Sq. Ft. Gal.	Quan. Req'd 100 Sq. Ft.	Approx. Price per gal	Labor Hours
Dehydratine No. 10	1/16	1	26	4 Gal.	$1.35	3
Hydrocide Mastic	1/16	1	20 25	5 Gal.	1.46	3
Hydrocide 700	1/16	1	20 25	5 Gal.	1.52	3
R.I.W. 232	1/16	1	20–25	5 Gal.	1.40	3
Tremco 103 Mastic						
Asphalt base	1/8	1	20	5 Gal.	0.88	3
Tar base	1/8	1	20	5 Gal.	1.52	3

Cost of 100 Sq. Ft. Water Resisting Plaster Coats Using Paste Integral Compound

Trade Name	Inches Thick	Mix. Prop.	Number Coats	Sacks Cement	Cu. Ft. Sand	Quantity Waterp'g	Approx. Price per lb./gal.	Mechanic Hours	Labor Hours
R.I.W. Toxement . . .	¾	1:2	2	3	6	4½ lbs.	.20	7	7
Sika No. 1	¾	1:2	2	3	6	1½ gal.	1.80	7	7
Sika No. 1	1	1:2	3	4	8	2 gal.	1.80	8	8

Prices are quoted in same units as quantities, viz: ½ lbs. 9 cts. lb.; 3 qts. 25 cts. qt., etc.

Cost of 100 Sq. Ft. of Water Resisting Plaster Coats Using Powdered Integral Water Repellents

Trade Name	Inches Thick	Mix. Prop.	Number Coats	Sack Cement	Cu. Ft. Sand	Quantity Waterp'g	Approx. Price per lb.	Mechanic Hours	Labor Hours
Hydratite	1	1:2	2	4	8	8 lbs.	$0.18	8	8
Hydrocide Powder	1	1:2	2	4	8	4 lbs.	.19	8	8
M.B. Pozzolith*	¾	1:2	2	3	6	¾ lbs.	.60	7	7
M.B. Pozzolith*	1	1:2	2	4	8	1 lbs.	.60	8	8
R.I.W. Toxement	¾	1:2	2	3	6	4½ lbs.	.20	7	7

*Dissolve 1 lb. in sufficient water to make 1-gal. solution.

Dehydratine No. 6.—A waterproofing trowel coating for uneven substructural masonry surfaces which cannot be effectually covered with a brush coating. A compound similar to Dehydratine No. 4 but furnished in plastic consistency to be applied with a trowel. Reinforced with asbestos fiber, thus forming when set, a webbed waterproofing coat.

It is recommended that surfaces first be primed with a brush

coating of Dehydratine No. 4, then Dehydratine No. 6 troweled on. 26 sq. ft. per gallon for coating $\frac{1}{16}$" thick.

Cost per 100 sq. ft. is as follows:

	Hours	Rate	Total	Rate	Total
1.5 gals. Dehydratine No. 4		$.....	$.....	$1.25	$ 1.88
Cement mason	1.2	.....	.....	6.50	7.80
4 gals. Dehydratine No. 6		.....	.....	1.35	5.40
Cement mason	3.0	.....	.....	6.50	19.50
Cost per 100 sq. ft.....	4.2		$.....		$34.58
Cost per sq. ft.....			.....		.346

Cost of 100 Sq. Ft. Water Resisting Plaster Coats Using Liquid Integral Admixtures

Trade Name	Inches Thick	Mix. Prop.	Number Coats	Bags Cement	Cu. Ft. Sand	Quantity Waterp'g	Approx. Price per gal.	Mechanic Hours	Labor Hours
Anti-Hydro.....	$\frac{3}{4}$	1:2	2	3	6	$\frac{3}{4}$ gal.	$1.70	7	7
Anti-Hydro.....	1	1:2	2	4	8	1 gal.	1.70	8	8
Aquatite.....	$\frac{3}{4}$	1:2	2	3	6	$\frac{3}{4}$ gal.	.90	7	7
Aquatite.....	1	1:2	2	4	8	1 gal.	.90	8	8
Hydratite.....	$\frac{3}{4}$	1:2	2	3	6	$\frac{3}{4}$ gal.	1.60	7	7
Hydratite.....	1	1:2	2	4	8	1 gal.	1.60	8	8
R.I.W. Toxement.....	$\frac{3}{4}$	1:2	2	3	6	$\frac{3}{4}$ gal.	1.00	7	7
R.I.W. Toxement.....	1	1:2	2	4	8	1 gal.	1.00	8	8
Sikacrete.....	$\frac{3}{4}$	1:2	2	3	6	$\frac{3}{4}$ gal.	.80	7	7
Trimix.....	$\frac{3}{4}$	1:2	2	3	6	$\frac{3}{4}$ gal.	1.28	7	7

MEMBRANE WATERPROOFING

Membrane waterproofing is constructed in place by building up a strong, waterproof and impermeable blanket with overlapping plies of tar or asphalt saturated open mesh cotton fabric or rag felt. The plies are coated and cemented together with hot coal tar pitch or waterproofing asphalt. There is always one or

more applications of pitch or asphalt than plies of felt or fabric except when it is necessary to lay a dry sheet on a wet surface in order to start work. Properly constructed membrane waterproofing is superior to all other types of waterproofing as it prevents the entrance of water, regardless of hydrostatic head, capillary attraction, cracks in the concrete and expansion joints.

Estimating the Quantity of Felt or Fabric Required for Membrane Waterproofing.—When estimating the quantity of felt or fabric required for waterproofing masonry or concrete walls, pits, floors, etc., it will be necessary to add a certain percentage for lap and waste. If the felt is applied to walls, it will be necessary to allow about 6″ to lap over the footings at the bottom, also a small allowance at the top of the walls above grade. This will average from 7½ to 10 percent of the total area to be waterproofed.

If the walls or floors are covered with a single thickness of felt or membrane, it will be necessary to lap each strip of felt 4″ to 6″, depending upon the specifications. As most felts are put up in 36″ rolls it will be necessary to add about 12 percent for waste for a 4″ lap, and 17 percent for a 6″ lap.

If the lap is 4″ wide and only a single thickness of felt is used, it will be necessary to add about 20 percent to the actual area to allow for laps and the additional felt required at the top and bottom of the wall. On floors it is customary to run the felt or membrane up the sides of the walls 4″ to 6″.

If the lap is 6″ and only a single thickness of felt is used, add about 25 percent to the actual wall or floor area for laps, etc.

When 2, 3, 4 or more plies of felt are used, it will not be necessary to allow for laps except at the ends of the wall or floor, as one thickness of felt overlaps the next without waste. However, extra material will be required at the tops and bottoms of the walls and where the paper runs up the sides of the walls 4″ to 6″. On work of this kind, add about 10 percent to the actual floor or wall area.

Waterproof Felt Required to Cover 100 Sq. Ft. of Surface

Class of Work	1 Ply 4″ lap	1 Ply 6″ lap	2-Ply	3-Ply	4-Ply	5-Ply	Ea. Add. Ply
Add percentage	20	25	10	10	10	10	10
Sq. Ft. Felt	120	125	220	330	440	550	110

All manufacturers sell saturated felt at a certain price per roll containing 432 sq. ft. Tar or asphalt saturated fabric is also sold at a certain price per roll containing 50 sq. yds.

Weight of Tar or Asphalt Felt for Membrane Waterproofing—Tar or asphalt felt for waterproofing is currently furnished in 4 sq. rolls of 432 sq. ft. weighing 60 lbs. per roll.

Double thickness asphalt felt is also furnished in 60 lb. per roll containing 216 sq. ft. and this felt is known as No. 30.

When specifying the grade or weight of felt to be used, it is customary to state that "felt shall weigh not less than 15 lbs per 108 sq. ft." This is known as No. 15 felt. Inasmuch as felt is furnished in 4 sq. rolls of 432 sq. ft. there are 32 sq. ft. per roll or 8 sq. ft. per 100 sq. ft. allowed for laps.

Tar or asphalt saturated fabric is usually sold by the roll containing 50 sq. yds. or by the sq. yd.

The itemized estimates on the following pages are based on using waterproof felt weighing 15 lbs. per 108 sq. ft., or 60 lbs to the roll of 432 sq. ft.

Estimating the Quantity of Pitch or Asphalt Required for Membrane Waterproofing.—The quantity of pitch or asphalt required for mopping 100 sq. ft. of surface with one application is approximately 30 to 35 lbs.

Many special coatings are sold under trade names. Some are furnished solid, making it necessary to heat and melt them before using, while others are furnished in the form of a heavy black paint that can be either mopped or brushed on cold. The manufacturers usually specify how their materials shall be applied.

Engineers and architects usually specify the quantity of asphalt or compound to be used for each 100 sq. ft. of surface.

Weight of Pitch or Asphalt Per 100 Sq. Ft. of Surface

No. Plies of Saturated Fabric or Tarred Felt	Alternate Moppings of Pitch or Asphalt Required	Lbs. of Pitch or Asphalt Required 100 Sq. Ft. Waterproofin
2	3	90 to 105
3	4	120 to 140
4	5	150 to 175
5	6	180 to 210
6	7	210 to 245

Applying Membrane Waterproofing.—Whether to use saturated fabric or saturated felt in constructing membrane waterproofings depends entirely upon local conditions. Saturated fabric weighing 12 oz. per sq. yd. has approximately three times the tensile strength of 15-lb. saturated felt, but it costs about three times more per sq. yd. than saturated felt. Tests have shown that the waterproofness of the completed membrane is not

dependent upon the selection of either fabric or felt as they are only used to hold the moppings of pitch and asphalt in place. On flat surfaces where the waterproofing will be covered with a protection course immediately after it is applied and where it will not be subjected to any unusual strain, saturated felts can be used. On vertical surfaces or on any surface where greater strength is required fabric should be used. Where protection courses are omitted a ply of fabric can be installed over the required number of plies of felt and the fabric will tend to protect the underlying felt plies from puncture by backfill. However, it is always desirable to provide a protection course over the waterproofing construction. While the labor operations involved in applying membrane waterproofing are similar to those followed in applying built-up roofing, the work is usually more expensive than roofing because of the limited working space and the necessity for using scaffolds on vertical surfaces over 10 feet high.

If asphalt is to be used the surface must be coated with an asphalt primer applied by brush or spray. When pitch is used the primer may be omitted.

On vertical surfaces the work can be expedited if the plies of felt or fabric are installed up and down the surface like wallpaper rather than across. The pieces of felt or fabric can be cut to the required length and folded so that after the surface has been mopped the top edges can be pushed into the hot bitumen and the remainder of the piece will then fall into place where it can be rubbed into the hot pitch or asphalt. After the required number of plies have been embedded in alternate moppings of hot bitumen all angles at corners, walls, etc., should be reinforced with at least two plies of felt or fabric and alternate moppings of bitumen. A protection course of cement mortar, brick or other material should immediately be placed over the waterproofing for best results.

Labor Applying Membrane Waterproofing.—When applying membrane waterproofing to walls and floors, three or four men usually work together, as it requires one man to attend the fire and heat the bitumen, while two or three men are mopping the walls and applying the felt or fabric.

If only one application of hot bitumen is applied, two men working together should heat materials and mop 2,000 to 2,200 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.8	$.....	$.....	$6.25	$5.00
Cost per sq. ft.					.05

Water Pressure Table and Waterproofing Required for Varying Heads of Water

Hydrostatic Head in Feet	Pressure per Sq. In. in Pounds	Lifting Pressure per Sq. Ft., Lbs.	Wall Pressure per Sq. Ft., Lbs.	Plies of Saturated Felt or Fabric	Asphalt Mastic Thickness
0.5	0.21	39.2	15.6	2-Ply	$\frac{1}{8}$ inch
1.0	0.43	62.5	31.2	2-Ply	$\frac{1}{8}$ inch
2.0	0.86	125.0	62.5	2-Ply	$\frac{1}{4}$ inch
3.0	1.30	187.5	93.7	2-Ply	$\frac{1}{4}$ inch
4.0	1.73	250.0	125.0	3-Ply	$\frac{5}{8}$ inch
5.0	2.17	312.5	156.2	3-Ply	$\frac{5}{8}$ inch
6.0	2.60	375.0	187.5	4-Ply	$\frac{5}{8}$ inch
8.0	3.47	500.0	250.0	4-Ply	$\frac{5}{8}$ inch
10.0	4.34	625.0	312.5	5-Ply	$\frac{5}{8}$ inch
12.0	5.21	750.0	375.0	6-Ply	$\frac{5}{8}$ inch
15.0	6.51	937.5	468.7	6-Ply	$\frac{3}{4}$ inch
20.0	8.68	1250.0	625.0	7-Ply	$\frac{3}{4}$ inch
25.0	10.85	1562.5	781.2	8-Ply	$\frac{3}{4}$ inch
30.0	13.02	1875.0	937.5	10-Ply	$\frac{3}{4}$ inch
40.0	17.36	2500.0	1250.0	11-Ply	$\frac{3}{4}$ inch

After the surface has been mopped with hot bitumen, it will be necessary for two men to cut the felt to lengths and place it on the wall. Usually it is cut long enough to lap over the top of the wall a few inches, so that it can be held in place by a brick or stone until it is self-supporting.

Two men placing felt or fabric have to work along with the men mopping, so they will place felt or fabric on 2,000 to 2,200 sq. ft. of surface per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.8	$.....		$6.25	$5.00
Cost per sq. ft.		$.....	.....		.05

Labor Applying 100 Sq. Ft. of Membrane Waterproofing

Number Plies	Description of Work	Mopping Hours	Felt Hours	Total Hours
1	1-ply fabric, 2 moppings	1.6	0.8	2.4
2	2-ply fabric, 3 moppings	2.4	1.6	4.0
3	3-ply fabric, 4 moppings	3.2	2.4	5.6
4	4-ply fabric, 5 moppings	4.0	3.2	7.2
1	Each additional ply of felt and mopping	0.8	0.8	1.6

Prices of Waterproofing Materials

Prices on waterproofing materials should be checked by the estimator, as prices vary considerably due to market conditions, geographical location and with the various manufacturers.

Asphalt primer, $0.35 to $0.50 per gal in 55-gal drums; $0.40 to $0.55 per gal. in 30-gal drums and $0.50 to $0.65 per gal. in 5-gal. cans.

Waterproofing pitch or asphalt $40.00 to $50.00 per ton in carload lots; $45.00 to $55.00 per ton in less than carloads.

No. 15 tar or asphalt saturated felt, $2.50 to $3.00 per roll of 432 sq. ft. in carloads and $2.65 to $3.15 per roll in less than carloads.

Tar or asphalt saturated cotton fabrics, $0.25 to $0.30 per sq. yd. in carloads and $0.30 to $0.35 per sq. yd. in less than carloads.

Cost of 100 Sq. Ft. of 1-Ply Membrane Waterproofing

Consisting of 1-ply 15-lb. felt and 2 moppings of hot bitumen.

	Hours	Rate	Total	Rate	Total
1 gal. asphalt primer		$.....	$.....	$0.65	$ 0.65
70 lbs. asphalt or pitch*..		.....	.....	.03	2.10
Labor	1.6	.....	.....	6.25	10.00
1.11 sq. rolls No. 15 felt...		.....	.....	.80	.89
Labor placing felt	0.8	.....	.....	6.25	5.00
Fuel, mops, etc.		.....	.....	.35	.35
Cost per 100 sq. ft.	2.4		$.....		$18.99
Cost per sq. ft.			.....		.19

Cost of 100 Sq. Ft. of 2-Ply Membrane Waterproofing

Consisting of 2 plies of felt and 3 moppings of hot bitumen.

	Hours	Rate	Total	Rate	Total
1 gal. asphalt primer		$.....	$.....	$0.65	$ 0.65
105 lbs. asphalt or pitch*.		.....	.....	.03	3.15
Labor	2.4	.....	.....	6.25	15.00
2.04 sq. rolls No. 15 felt...		.....	.....	.80	1.63
Labor placing felt	1.6	.....	.....	6.25	10.00
Fuel, mops, etc.		.....	.....	.50	.50
Cost per 100 sq. ft.	4.0		$.....		$30.93
Cost per sq. ft.			.....		.309

*Asphalt primer not required when coal tar pitch is used.

Cost of 100 Sq. Ft. of 3-Ply Membrane Waterproofing

Consisting of 3 plies of felt and 4 moppings of hot bitumen.

	Hours	Rate	Total	Rate	Total
1 gal. asphalt primer		$.....	$.....	$0.65	$ 0.65
140 lbs. asphalt or pitch*..		.....	.....	.03	4.20
Labor	3.2	.....	.....	6.25	20.00
3.06 sq. rolls No. 15 felt..		.....	.....	.80	2.45
Labor placing felt	2.4	.....	.....	6.25	15.00
Fuel, mops, etc.		.....	.....	.60	.60
Cost per 100 sq. ft.	5.6		$.....		$42.90
Cost per sq. ft.			.....		.429

Cost of 100 Sq. Ft. of Each Additional Ply of Felt and Hot Bitumen

	Hours	Rate	Total	Rate	Total
35 lbs. asphalt or pitch...		$.....	$.....	$0.03	$ 1.05
Labor	0.8	.....	.....	6.25	5.00
1.02 sq. rolls No. 15 felt..		.....	.....	.80	.82
Labor placing felt	0.8	.....	.....	6.25	5.00
Fuel, mops, etc.		.....	.....	.15	.15
Cost per 100 sq. ft.	1.6		$.....		$12.02
Cost per sq. ft.			.....		.120

Cost Per 100 Sq. Ft. for Each Additional Mopping of Hot Bitumen

	Hours	Rate	Total	Rate	Total
35 lbs. asphalt or pitch..		$.....	$.....	$0.03	$ 1.05
Labor	0.8	.....	.....	6.25	5.00
Fuel, mops, etc.		.....	.....	.15	.15
Cost per 100 sq. ft.	0.8		$.....		$6.20
Cost per sq. ft.			.....		.062

Cost of 100 Sq. Ft. of 2-Ply Membrane Waterproofing Using Tar or Asphalt Saturated Fabric and Hot Pitch or Asphalt

Consisting of 2-plies of saturated fabric and 3 moppings of hot bitumen.

	Hours	Rate	Total	Rate	Total
1 gal. asphalt primer		$.....	$.....	$0.65	$ 0.65
105 lbs. asphalt or pitch ..		.....	.....	.03	3.15
Labor	2.4	.....	.....	6.25	15.00
25 sq. yds. satur. fabric ..		.....	.....	.35	8.75
Labor placing fabric	1.6	.....	.....	6.25	10.00
Fuel, mops, etc.		.....	.....	.50	.50
Cost per 100 sq. ft.	4.0		$.....		$38.05
Cost per sq. ft.			.....		.381

*Asphalt primer not required when coal tar pitch is used.

Cost of 100 Sq. Ft. of 3-Ply Membrane Waterproofing Using Tar or Asphalt Saturated Fabric and Hot Pitch or Asphalt

Consisting of 3-plies of saturated fabric and 4 moppings of hot bitumen.

	Hours	Rate	Total	Rate	Total
1 gal. asphalt primer		$.....	$.....	$0.65	$ 0.65
140 lbs. asphalt or pitch ..		.....	.....	.03	4.20
Labor	3.2	.....	.....	6.25	20.00
37 sq. yds. satur. fabric..		.....	.....	.35	12.95
Labor placing fabric.....	2.4	.....	.....	6.25	15.00
Fuel, mops, etc.		.....	.....	.60	.60
Cost per 100 sq. ft. ...	5.6		$.....		$53.40
Cost per sq. ft.			.....		.534

Cost of 100 Sq. Ft. of Each Additional Ply of Saturated Fabric and Hot Pitch or Asphalt

	Hours	Rate	Total	Rate	Total
35 lbs. asphalt or pitch ..		$.....	$.....	$0.03	$ 1.05
Labor	0.8	.....	.....	6.25	5.00
12 sq. yds. satur. fabric..		.....	.....	.35	4.20
Labor placing fabric	0.8	.....	.....	6.25	5.00
Fuel, mops, etc.		.....	.....	.15	.15
Cost per 100 sq. ft.	1.6		$.....		$15.40
Cost per sq. ft.			.....		.154

Cost Per 100 Sq. Ft. for Each Additional Mopping of Hot Pitch or Asphalt

	Hours	Rate	Total	Rate	Total
35 lbs. asphalt or pitch..		$.....	$.....	$0.03	$1.05
Labor	0.8	.....	.....	6.25	5.00
Fuel, mops, etc.		.....	.....	.15	.15
Cost per 100 sq. ft.	0.8		$.....		$6.20
Cost per sq. ft.			.....		.062

THE IRON METHOD OF WATERPROOFING

The iron method of waterproofing uses an exceedingly fine metallic powder, containing no grease, asphalt, oil or other substances subject to disintegration.

The waterproofing is applied to the inside or outside surfaces of walls after all forms are removed, and to the tops of rough footings and floor slabs, in the form of brush coats or in a combination of brush and plaster coats.

Applied either upon the inside or outside of walls, this type of waterproofing will resist hydrostatic pressure to a considerable degree.

When preparing vertical surfaces for iron waterproofing, the vertical surfaces shall be given an entirely new bonding exposure by cutting not less than $\frac{1}{16}$" with bush-hammers or other suitable tools. See cost of roughing old surfaces on previous pages. A new surface shall then be thoroughly cleaned by brushing with wire brushes. Surfaces of brick and stone need only thorough cleaning with the wire brush.

Holes, cracks, and soft or porous spots in vertical or horizontal surfaces shall be cut out and pointed with one part iron floor bond, 2 parts portland cement and 3 parts sand, all by weight. These materials shall be mixed dry, screened and enough water added to make a stiff mix. Particular care must be taken at the intersections of all walls and floors, in corners, around pipes and other projections through the waterproofing and at construction joints in the concrete.

After the wall surfaces have been cleaned and pointed, they shall be thoroughly cleaned again by hosing. Excess water shall then be removed.

It usually requires 2 to 6 coats of iron waterproofing, depending upon the density of the concrete and the conditions encountered.

Some of these materials are mixed with sand and water and applied as a brush coat while others are furnished already mixed ready to apply by the addition of water.

Cost of 100 Sq. Ft. of 1-Coat Waterproofing Using the Iron Method, Brushed On

Trade Name	Number Coats	Quan. Req'd 100 Sq. Ft.	Approx. Cost Lb.	Labor Hrs. Applying
Ferrocon Aquabar	1	10-15 lbs.	$.12	2
Ferrolith W	1	13-15 lbs.	.21	2
Kemox W (Sika)	1	60 lbs. to 100 lbs.	.13	2
M. B. Embeco No. 5...	1	10 lbs.	.15	2
Metalon	1	12½ lbs.	.20	2
R.I.W. Irontox	1	10-12 lbs.	.12	2

For each additional application, figure same as given above.

Three to five applications are required where there is water pressure to be overcome.

Dampproof paints for Exterior Concrete or Masonry Surfaces

Where a heavy head of water is to be overcome, the concrete or masonry should preferably be waterproofed by the mem-

brane method. Where only a dampproofing material is required, there are a number of paints on the market for this purpose. The application of one, two or more coats of paint is intended to make the walls impervious to dampness.

Cost of 100 Sq. Ft. Heavy Dampproof Paints

Name of Material	Recommended for use on	No. Cts.	Sq. Ft. per Gal.	Gals. Reqd. 100 Sq. Ft.	Price per Gal.	Lab. Hrs. Applying
Aquabar Marine . .	Fndtn. Walls	1	60	1⅔	$.95	1.2
Aquabar Marine . .	Fndtn. Walls	2	40	2½	.95	2.2
Dehydratine 4	Fndtn. Walls	2	33	3	1.25	2.2
Dehydratine 10 . . .	Mason Walls	1	30	3⅓	1.35	1.2
Hydrocide Semi-Mastic	Fndtn. Walls	1	30–35	3	1.46	1.2
	Fndtn. Walls	2	15–18	6	1.46	2.2
Hydrocide 600	Fndtn. Walls	1	75–100	1⅓	1.52	1.2
Hydrocide 648	Fndtn. Walls	2	50	2	1.40	2.2
R.I.W. Marine Liquid	Below Grade	1	50–75	1¾	.90	1.2
Sika Seal	Fndtn. Walls	2	60–80	1½	1.80	2.2
Tremco 110	Fndtn. Walls	1	100	1	.79	1.2

For water and dampproofing foundation and basement walls, exterior masonry, etc.

Number of coats required and covering capacity will vary with porosity and surface of wall.

Labor Applying Water and Dampproofing Paint to Exterior Surfaces Below Grade.—Where the water or dampproofing consists of applying one or more coats of heavy black paint to exterior concrete or masonry surfaces below grade, it is customary to use an ordinary roofer's brush or a mop. On foundation walls below grade, the men are usually obliged to work in cramped quarters which reduces output.

To make these paints effective, they must be thoroughly brushed into the surface and all voids and pin holes filled, otherwise water and moisture will seep through.

On work of this kind, a man should apply 600 to 700 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	1.3	$.	$.	$5.00	$6.50
Cost per sq. ft.					.065

On the second and third coats the labor cost will be slightly less than the first coat on account of the smoother surface to work on.

Dampproof and Plaster Bond Paints

Instead of placing wood or metal lath or hollow tile wall furring on the inside of exterior masonry walls that are to be plastered, they are often painted with a heavy black paint that is used to prevent dampness from coming through the walls and which also acts as a plaster bond.

Labor Applying Dampproofing and Plaster Bond Paints.—Before applying the first coat of plaster to the interior of exterior brick or masonry walls, the walls are often painted with one or more coats of heavy black paint, which acts as a dampproofing and plaster bond.

The labor cost will vary with the consistency of the paint and the condition of the walls, as the paint must be well brushed in and all pin holes and porous places thoroughly covered with paint, otherwise moisture will seep through the walls.

Where the paint is applied by hand, a man should cover 700 to 800 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	1.1	$.....	$.....	$5.00	$5.50
Cost per sq. ft.			.....		.055

When the dampproof paints are applied with an air spray, a man should cover 300 to 350 sq. ft. per hr. at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.33	$.....	$.....	$6.00	$2.00
Cost per sq. ft.			.....		.020

Cost of 100 Sq. Ft. Dampproof and Plaster Bond Paints

Heavy black paints used for dampproofing interior of exterior walls and to form a bond for plaster. Number of coats required will depend upon porosity of wall on which it is used.

Labor costs in the following table are based on hand application. If an air spray is used, deduct as given above.

Name of Material	No. Coats	Sq. Ft. per Gal.	Gals. Reqd. 100 Sq. Ft.	Price per Gal.	Labor Hrs. Applying
Dehydratine 4	1	70–80	1⅓	$1.25	1.0
Dehydratine 4	2	45–55	2⅓	1.25	1.9
R.I.W. No. 232	1	75-80	1⅓	1.40	1.0
R.I.W. No. 232	2	35-40	2½	1.40	1.9

Transparent Dampproofing of Exterior Masonry Walls

During the past few years there has been a big change in the use of transparent dampproofings and the method of application due to an investigation by the National Bureau of Standards, Publication BMS7.

From the results of this investigation it was determined that "leaky" walls were mainly caused by poor workmanship. In other words, unless the bricks were laid in a full bed of mortar (not furrowed), with all bed, end and vertical joints completely filled with mortar, the walls were likely to leak within a short period after the completion of the structure. A hairline crack between the brick and mortar joints was also given as a cause of leakage. For a more complete description of causes of leakage in masonry walls, refer to following pages.

From these tests it was determined that only painting the surfaces of masonry walls with transparent "paints" or "waxes" did not stop these leaks and one method that was really efficient was to cut out the old mortar joints to a depth of ½ to ¾-in., repointing with mortar and then waxing the joints with a special paraffin wax solution to prevent moisture and water absorption by the mortar.

This class of work is quite expensive as the cost depends upon the hardness and tenacity of the mortar joints that must be cut out.

The basis for the use of exterior waterproofing, labor and material, is calculated on the ordinary wall constructed with common brick of high absorption with ½ to ⅝-in. lime-cement mortar joints.

On lime-cement mortar joints, two men can rake out and repoint about 12 sq. ft. of brick masonry surface an hour, remov-

ing joints to a depth of ¾-in. Allow about ¼-hr. helper's time for moving swinging scaffolds or erecting scaffolds.

Two men can wax and dampproof about 125 sq. ft. of joints an hour and will require not less than one gallon of dampproofing to 75 sq. ft. of wall per coat.

On the above basis, the cost of cutting out old mortar joints, repointing mortar joints and applying waterproofing wax to 100 sq. ft. of wall surface will cost as follows:

	Hours	Rate	Total	Rate	Total
Mason	16.0	$.....	$.....	$7.10	$113.60
Helper	4.0	.....	.....	5.20	20.80
2 cu. ft. 1:1:6 mortar		.....	.....	.603	1.21
Waxing Joints					
Mason	1.6	.....	.....	7.10	11.36
1⅓ gal. paraffin wax		.....	.....	3.60	4.80
Cost per 100 sq. ft.	21.6		$.....		$151.77
Cost per sq. ft.			.....		1.52

On hard portland cement mortar joints, one man using an air compressor and tools can cut out joints in about 1¼ sq. ft. of wall per hour and requires ½-hr. helper time handling and sharpening tools and will require about 2 tools per hour which have to be reforged and reconditioned at about 50 cts. each.

On the above basis, the cost of cutting out old 1:3 portland cement mortar joints, repointing joints and applying waterproofing wax to 100 sq. ft. of wall will cost as follows:

	Hours	Rate	Total	Rate	Total
Mason cutting out joints	80	$.....	$.....	$7.10	$568.00
Mason pointing joints	4	.....	.....	7.10	28.40
Helper	45	.....	.....	5.20	234.00
2 cu. ft. 1:1:6 mortar		.....	.....	.603	1.21
Reforging and resharpening tools, 160		.....	.....	.50	80.00
Waxing Joints					
Mason	1.6	.....	.....	7.10	11.36
1⅓ gal. paraffin wax		.....	.....	3.60	4.80
Cost per 100 sq. ft.	130.6	.....	$.....		$927.77
Cost per sq. ft.			.....		9.28

Add cost of compressor, fuel, scaffold, overhead and profit.

Ordinary electric saws, hammers and grinding wheels do not work on these joints.

Colorless or Transparent Liquid Water Repellent Treatments

There are a number of colorless or transparent liquid preparations on the market used on brick, stone, stucco, cement and concrete surfaces to render them water repellent and help to prevent rain absorption.

These liquids are colorless and do not affect the original color of the surface to which they are applied.

The covering capacities and quantities given in the following table were furnished by the various manufacturers.

It will be noted that some manufacturers specify one coat and others two coats. Regardless of the material used, sufficient liquid must be applied to completely seal the pores of the surface, otherwise the results will be unsatisfactory.

Cost of 100 Sq. Ft. Transparent Liquid Water Repellents

Transparent liquids used for dampproofing brick, stone, stucco, concrete and cement surfaces without changing the color of the surface treated.

Name of Material	No. Coats	Sq. Ft. per Gal.	Gals. Reqd. 100 Sq. Ft.	Price per Gal.	Labor Hrs. Applying
Daracone	1	75-100	1¼	$3.85	1.6
Hydrocide G-101	2	65-75	1½	3.19	1.6
R.I.W. Supertox	1	125-150	¾	3.00	0.8
R.I.W. Limestone sealer	1	125-150	¾	3.00	0.8
Tremco 141 Invisible	2	75-100	1¼	2.95	1.6

Colorless or Transparent Silicone Base Liquid Water Repellent Treatments

Recent developments in liquid water repellent treatments are the new silicone base products which are truly colorless and permit the masonry to "breathe" while rendering the surface water repellent. They penetrate deeply into the cement or masonry surfaces coating pores, cracks and fissures with an insoluble, non-oxidizing film of silicone which effectively stops capillary action by which water is absorbed.

Usually one flooding coat is sufficient and may be applied by either brushing or spraying.

The covering capacities and quantities given in the following table were furnished by the various manufacturers.

Cost of 100 Sq. Ft. Silicone Base, Transparent Liquid Water Repellents

Name of Material	No. Coats	Sq. Ft. Per Gal.	Gals. Req'd. 100 Sq. Ft.	Price Per Gal	Labor Hours Applying
Dehydratine 22	1	75-100	1¼	$3.50	0.8
Hydrocide Colorless SX	1	75-100	1	4.08	0.8
Sika Transparent	1	80-200	⅔	2.40	0.8
Tremco 147-3%	1	100-200	⅔	4.25	0.8
Tremco 147-5%	1	100-200	⅔	5.75	0.8
Devoe Super-Por-Seal	1	150	⅔	4.06	0.8

Labor Applying Transparent Liquid Waterproofing.—When applying transparent liquid damproof paints by hand, a man should cover 900 to 1,100 sq. ft. of surface per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.8	$.....	$.....	$5.00	$4.00
Cost per sq. ft.					.04

On the second and third coats, a man should apply 1,000 to 1,200 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.75	$.....	$.....	$5.00	$3.75
Cost per sq. ft.			.....		.038

When applied with an air brush, a man should cover 300 to 350 sq. ft. per hr. at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.33	$.....	$.....	$6.00	$2.00
Cost per sq. ft.					.020

Add cost of compressor and air brush equipment.

Back-Plastering and Back-Painting Cut Stone and Marble to Prevent Staining

When marble, limestone, brownstone or sandstone are used in building work, considerable difficulty is encountered in preventing the moisture in the brick or concrete backing from penetrating the surface of the stone or marble and staining or

discoloring the face. This is due to the open grain or porous nature of the stone or marble.

To overcome this condition it is customary to paint the back of the stone, beds and end joints up to within 1″ of the face to prevent staining and discoloration. White or non-staining cement is also used for this purpose. The stone is set in non-staining cement mortar and the back of the stone is plastered or parged with the same mortar.

In many instances the backs, beds, and joints of the stone are painted and then back-plastered with non-staining cement which acts as a double preventative.

Back-painting of Indiana limestone is not recommended by quarrymen and producers because they state it tends to create conditions it is supposed to counteract. A full explanantion is given under Cut Stone.

Where cut stone comes in contact with concrete, it is recommended that the concrete be painted instead of the stone and a one inch space left between the concrete and cut stone.

Estimating the Cost of Back-Painting Cut Stone and Marble.—Inasmuch as it is customary to estimate the cost of cut stone by the cu. ft. the cost of back-painting should be estimated in the same manner.

Plain stone ashlar is usually 4″ to 8″ thick or in alternating courses of 4″ and 8″ stone so as to provide a bond with the brick or masonry backing. Where just a veneer of cut stone is required, the stone is usually 4″ thick and is bonded into the masonry backing by metal anchors.

If cut stone is furnished in alternating courses of 4″ and 8″, the stone for the entire job will average 6″ thick. It will therefore be necesary to back-paint 2 sq. ft. of surface to each cu. ft. of stone. Including beds and joints, it will double the above quantities or it will be necessary to back-paint $4\frac{1}{3}$ sq. ft. of surface to one cu. ft. of stone.

If the stone averages 4″ thick, it will be necessary to back-paint about 5 sq. ft. of surface to each cu. ft. of stone, including the backs, beds, and joints.

If the stone averages 8″ thick, it will be necessary to back-paint about 4 sq. ft. of surface to each cu. ft. of stone.

Back-Painting Cut Stone and Marble.—When back-painting limestone, sandstone, marble, etc., the stone is often painted in the yard before delivery, although on many jobs it is painted after delivery. It is customary to paint the stone a few days before setting, although the backs are frequently painted after the stone has been set.

Care must be exercised to thoroughly brush the paint into all the pores and not drop any paint on the face of the stone.

When painted at the building site, a man should paint 600 to 700 sq. ft. of surface per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	1.3	$.....	$.....	$5.00	$6.50
Cost per sq. ft.			.....		.065

Back-Painting 100 Sq. Ft. Cut Stone or Marble to Prevent Staining

Heavy black paints applied to backs and sides of stone to prevent cement and mortar stains. Quantities based on 1 coat.

Name of Material	Sq. Ft. per Gal.	Gals. Reqd. 100 Sq. Ft.	Price per Gal.	Labor Hours
Dehydratine 4	100	1.00	$1.25	1.3
Hydrocide No. 648	125–175	0.75	1.40	1.3
Sika Seal	120	0.80	1.80	1.3

Number of Cu. Ft. of Stone to be Painted Per 100 Sq. Ft. of Surface

Includes back, beds and end joints

Average Thickness of Stone				
4"	6"	8"	10"	12"
20	23	25	28.5	31

Number of Sq. Ft. of Painted Surface in One Cu. Ft. of Stone

Includes back, beds and end joints

Average Thickness of Stone				
4"	6"	8"	10"	12"
5	4.3	4	3.5	3.2

Back-Plastering Cut Stone and Marble.—After the stone or marble has been set, it is customary to plaster the back of the stone with non-staining cement, using an ordinary trowel and applying it $\frac{3}{16}$" to $\frac{1}{4}$" thick.

Inasmuch as the stone must be back-plastered as the setting progresses, so as not to delay the bricklayers in backing-up the stone, the time required is rather indefinite. Working

steadily, however, a mason should back-plaster 65 to 75 sq. ft. an hr. at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
70 lbs. white cement.....		$.....	$.....	$0.04	$ 2.80
2.2 cu. ft. fine white sand		.....	.....	1.20	2.64
7 lbs. hydrated lime.....		.....	.....	.02	.14
Mason or stone setter....	1.5	.....	.....	7.10	10.65
Cost per 100 sq. ft.....	1.5		$.....		$16.23
Cost per sq. ft.....			.....		.162

CEMENT FLOOR HARDENERS

There are many preparations on the market for waterproofing, dustproofing and wearproofing cement finish floors. These preparations fall into two classifications, integral treatments in which the entire slab or topping is treated and surface treatments in which the surface is specially prepared to become waterproof, dustproof and wear resistant.

Integral Treatments.—Integral treatments consist of powdered chemicals that are mixed with the cement before sand and water are added and become an integral part of the topping mix throughout its entire thickness. This type of treatment is said to densify and harden the topping and is generally recommended for areas subjected to light pedestrian traffic.

Surface Treatments.—There are two types of surface treatments for cement finish floors, shake or dust coat applications which must take place as floors are being finished and liquid chemical applications which may be done at any time after the floor finish is set hard enough for foot traffic.

METALLIC FLOOR TREATMENTS (HARDENERS)

By far the most wide spread surface treatment is the metallic dust coat. The term "hardeners" usually applied to metallic floor treatments is somewhat misleading since iron has a much lower rating on the scale of hardness than even the most common sand or stone aggregate. In this sense iron treatments could be described as "softeners" since the basic technique is to provide a floor surface wherein the hard, brittle sand and stone found in plain concrete is overlaid with a coating of soft, ductile iron. It is reasoned that where hard, brittle aggregates crush under impact and abrasion, iron particles are malleable under these forces and will not fracture or crush out of the floor surface.

Metallic floor treatments consist of a dust coat application of

pulverized iron, size graded to pass through mesh screens in the following proportions:

	Percent Passing
4 mesh screen	100 percent
8 mesh screen	Not less than 90 percent
14 mesh screen	Not less than 70 nor more than 85 percent
28 mesh screen	Not less than 35 nor more than 50 percent
48 mesh screen	Not more than 10 percent
100 mesh screen	Not more than 5 percent

Iron particles of the above graduation are mixed with cement and dusted onto freshly floated concrete and then floated and troweled to a smooth even finish. This optimum grading produces a more workable material while plastic and provides a dense surface having great resistance to wear upon hardening.

The iron material should be free from oil and should contain no non-ferrous metals. Oil will prevent the cement paste from bonding properly to the iron particles and non-ferrous metals may react with the cement to form gases and cause serious surface blistering.

Manufacturers, architects and engineers specify different methods and amounts of iron to be used, which is usually a certain number of pounds of iron mixed with one half that weight of cement. The material is dusted over the floor surface before the finish topping has taken its initial set. These quantities vary from 30 to 120 pounds of iron per 100 sq. ft. of floor, depending upon the traffic the floor will have to withstand. When the heavier dust coats are used, water-reducing and plasticizing agents are required to produce a dust coat that can readily be worked onto the surface without resorting to an overly wet concrete mix. In wet mixes there is danger that the iron aggregate will sink into the concrete where it serves no benefit as surface armoring.

It is not necessary to add anything to the labor costs of applying the regular cement finish top. It merely means that the finisher dusts the floor with the metallic powder while it is still too wet to trowel. By adding this dust coat it is possible to trowel the floor sooner than it would be without it, as it absorbs a portion of the surface water.

If the cement finish top is applied after the rough concrete base has set, it will be necessary to hack or roughen the surface and then thoroughly wash same with muriatic acid and water in the proportions of 1:5. The rough concrete base must be thoroughly soaked with water until it can absorb no more.

While the concrete base is still damp, apply a thin coat of

grout mixed in the proportions of 1 part iron particles, 1 part portland cement, 1½ parts clean water. This should be applied with a brush, using a scouring motion, taking care to coat all the surface. The topping material should be placed before the grout bond coat has dried.

To clean the old surface, flush same and apply the grout coat, estimate as follows per 100 sq. ft.:

Clean old surface	Hours	Rate	Total	Rate	Total
1 qt. muriatic acid		$.....	$.....	$0.30	$ 0.30
Labor	3	.....	.....	5.00	15.00
Grout Coat					
15 lbs. metallic hardener		.....	.....	0.15	.75
15 lbs. portland cement..		.....	.....	0.019	.29
Labor	2	.....	.....	5.00	10.00
Cost per 100 sq. ft. ...	5		$.....		$26.34
Cost per sq. ft.			.....		.263

Colorundum (W. R. Grace Co.).—A dry powder composed of powerful coloring mediums, fused aggregates, dampproofing and hardening elements, and cementitious binders.

For interior and exterior concrete floors. Applied as a dust coat during troweling. Requires 30 to 40 lbs. per 100 sq. ft. of floor area. Colors: Red, maroon, tan, buff, terra cotta, brown, French gray and black, 35 cts. lb.; Egyptian green and dark green 48 cts. lb.

Colorundum Sealer (W. R. Grace Co.).—A specially developed sealer consisting of pigment and reducer, packed separately, to be mixed on the job in equal parts by volume. The purpose of the sealer is to deepen the color and produce a uniformity in finished appearance. Designed to minimize construction traffic stains, retard efflorescence, seal in moisture and to assist in proper curing of the topping.

For application on new Colorundum floors. Brush application of one coat may be applied as soon as the floor can be walked upon without marring the surface.

Covers approximately 350 sq. ft. per gallon. Bear in mind that one gallon of pigment and one gallon of reducer, produces two gallons of corundum sealer.

Two gallon unit (1-gal. pigment and 1-gal. reducer), $18.00.

Durocon Metallic Floor Hardener (Aquabar).—A specially prepared metallic hardener for industrial and heavy duty concrete floors. Contains ocon, which provides concrete of increased strength, resisting acid, alkali, etc.

For average traffic, 30 to 40 lbs. hardener and 30 lbs. portland cement; for heavy traffic, 50 lbs. hardener and 30 lbs. portland cement; and for extra heavy traffic, 60 lbs. hardener and 30 lbs. portland cement per 100 sq. ft. floor.

Use 40 lbs. colored Durocon with 20 lbs. portland cement per 100 sq. ft.

Standard colors, natural, tile red, linoleum brown, French gray, Persian red, battleship gray, Nile green, black, russet and maroon.

Furnished in 100-lb. bags. Price in ton lots, natural, 7 cts. lb. Colors slightly higher.

Duroplate (Aquabar).—Specially prepared, size-graded iron particles combined with Aquabar dispersing agent. Applied as a dust coat while concrete is still in a plastic condition and machine floated into the surface. Renders floors spark resistant, non-dusting, erosion resistant and can be given a non-slip finish if desired. Use 60 to 120 lbs. per 100 sq. ft. of floor depending on degree of duty required.

Prices: Non-colored, 8 cts. per lb.; tile red and other standard colors, except green, 12 cts. per lb.; green 22 cts. per lb.

Durundum Non-Slip Hardener (Aquabar).—An aggregate floor hardener composed of powerful coloring mediums and hardening elements plus cementitious binders. Non-rusting and produces a non-slip surface. Entirely inert, very hard, tough and abrasive resistant. Apply as a dust coat from 30 to 60 lbs. per 100 sq. ft. as conditions require.

Prices: Natural and standard colors, 8 cts. per lb.; green, 16 cts. per lb.

Ferro-Fax Metallic Floor Hardener (W. R. Grace Co.).—Ferro-Fax metallic floor hardener meets government specifications. Free from oil and foreign metals. Produces wearproof, waterproof, dustproof concrete floors. Apply as a dust coat, using 30 lbs. per 100 sq. ft. for light traffic; 40 lbs. per 100 sq. ft for moderate traffic; heavy-duty floors, 70 to 100 lbs. per 100 sq. ft.

The Monolithic method is recommended for use in warehouses, factories, foundries, loading platforms, etc.

The concrete slab should be a mixture of 1:2:4 or 1:2.5:5, and the gravel shall pass a 1-inch screen.

Immediately following the leveling, deposit upon the surface a uniform dry mixture consisting of 1 sack (100 lbs.) Ferro-Fax; 2 sacks portland cement; 3 sacks clean, coarse sand.

This dry batch shall be mixed thoroughly and evenly dusted over the surface in the proportion of 50 lbs. of this mixture per 100 sq. ft. and shall then be thoroughly floated with heavy wooden floats, but not steel troweled.

Then immediately dust on the dry mixture of 2 parts Ferro-Fax and 1 part portland cement in the quantity specified for the job, as given above.

Price per lb. is approximately 12 cts.

Price 25 cts. per lb. in 100-lb. bags.

M. B. Colorcron.—A specially graded hard silica aggregate, combined with light-fast and alkali-fast coloring pigments, selected cement and a water-reducing agent which will produce a tough, wear-resistant floor surface.

Ready to use as it comes from the bag, the material is applied as a dust coat to freshly floated concrete floors at the rate of 50 lbs. per 100 sq. ft.

Available plain and in the following colors.

Price per lb.: Tile red, French gray, battleship gray, seal brown, black, 7 cts.; Nile green, 14 cts.

M.B. Masterplate.—Specially prepared metallic aggregate combined with a water reducing and cement dispersing agent. Makes possible the incorporation of 60 to 120 lbs. of iron on the surface to provide maximum resistance to abrasion under the heaviest of industrial traffic.

Average duty floors, 60 lbs. Masterplate plus 30 lbs. cement per 100 sq. ft.; heavy duty floors, 90 lbs. Masterplate plus 45 lbs. cement; extra heavy duty floors, 120 lbs. Masterplate plus 60 lbs. cement.

Prices: Tile red, Persian red, maroon, seal brown, terra cotta, 12 cts. lb.; Nile green 25 cts. lb.

M. B. DPS Masterplate.—A complete ready to use product containing specially processed iron aggregate, a conductive cement binder and a water-reducing and plasticizing agent. Applied as a dust coat at the rate of 180 lbs. per 100 sq. ft. of floor surface, DPS Masterplate meets federal and industrial requirements for conductive flooring. It retains its conductivity at temperatures from —20° to 150° F. and provides an extremely heavy duty floor that is spark-resistant and static-disseminating. Dark gray in color.

Price, 16 to 18 cts. lb., depending upon quantity.

M. B. Metalicron.—A specially processed iron aggregate, size graded and combined with efficient plasticizing agents and packaged free of rust. Mixed with cement at the job site, 2 parts aggregate to 1 part cement by weight, it is applied as a dust coat to freshly floated concrete at the rate of 30 to 60 lbs. of mixture per 100 sq. ft. Gives the tough, wear-resistant qualities of iron to concrete floors.

Price, 10 to 12 cts. lb., depending upon quantity.

Ferricon Metallic Floor Hardener (Devoe Paint, Div. Celanese Coatings Co.).—Ferricon is a metallic floor hardener that is free from oil, non-ferrous metals, and other impurities. Its use replaces the brittle, dusting, granular properties of a cement floor with the toughness, ductility and wear-resistant properties of a metallic surface.

Ferricon is used in the proportions of 2-100 lb. sacks of Ferricon to one sack of portland cement.

Light Duty Floors—30 lbs. hardener and 15 lbs. portland cement per 100 sq. ft.

Moderate Duty Floors—50 lbs. hardener and 25 lbs. portland cement per 100 sq. ft.

Heavy Duty Floors—60 lbs. hardener and 30 lbs. portland cement per 100 sq. ft.

Extra Heavy Duty Floors—120 lbs. hardener and 60 lbs. portland cement per 100 sq. ft.

Natural color, $12.46 per 100 lbs.

Art-Roc Aggregate (Devoe Paint, Div. Celanese Coatings Co.).—A colored aggregate hardener which is non-corrosive, and non-rusting, therefore may be used outdoors as well as indoors. Gives the effect of "built-in" color and hardness on concrete floors. Supplied ready to use. Packed in 67½ lb. drums.

Prices 16 cts. lb. for red and 24 cts. lb. for green.

Harcol R. M. (Sonneborn).—A ready to use, rustproof, dry mix of abrasive resistant aggregates, specially selected for their flint-like hardness, portland cement and limeproof pigments of high and uniform tinctorial strength.

Applied as a dust coat at the rate of 30 to 45 lbs. per 100 sq. ft., floated into the surface and troweled. Harcol produces an integrally colored surface highly resistant to abrasion.

Colors: bright red, dark red, gray, terra cotta and green.

Prices: green, 32 cents. per lb.; all other colors, 19 to 21 cts. per lb.

Ferrolith-H. (Sonneborn).—A finely ground metallic water-absorbent hardener, free from oils and impurities.

Requires 30 lbs. per 100 sq. ft. for ordinary traffic, 40 lbs. for medium traffic, 60 lbs. for heavy traffic and 100 lbs. for spark resistant floors. Price, plain metallic hardener, 18 cts. per lb.

Ferrocon Metallic (Aquabar).—Finely powdered iron mixed with sand, cement and water. Prevents absorbtion of moisture and seepage of water. For use on old and new structures. 3 to 5 coats recommended for pressure. Use 10 to 15 lbs. per 100 sq. ft. per coat.

Price: 12 cts. per lb. in 100-lb. steel pails.

Kemox H (Sika).—A metallic hardener to be used for areas subject to heavy steel wheel traffic.

For monolithic metallic floors, mix 100 lbs. Kemox H, 2 sacks portland cement, 3 cu. ft. clean sand. Sprinkle evenly over 1,000 sq. ft. of freshly placed, concrete floor slab. Trowel with float.

For finish coat, mix 200 lbs. Kemox H with 1 sack portland cement, immediately after floating preliminary finish spread over 300 sq. ft. for heavy duty; 1,000 sq. ft. for light duty floors. Steel trowel again when set starts. Price 12 cts. lb. in 100 lb. bags.

R.I.W. Irontox Hardener.—A dust-on hardener giving a hard wearing surface to cement flooring. Floors subject to normal traffic, 30 lbs. per 100 sq. ft.; heavier traffic floors, 40 lbs. per 100 sq. ft. and for heavy duty floors, 50 lbs. per 100 sq. ft. Price 9 to 12 cts. per lb. depending upon quantity.

R.I.W. Rocktop.—A chemically inert blend of non-metallic aggregates, pure mineral colors and cementitious materials in a ready-to-use form in red, buff, maroon, brown, gray and green. Requires 30 to 45 lbs. per 100 sq. ft. Red, buff, maroon, brown and gray, 10 cts. per lb.; green, 18 cts. per lb.

Liquid Chemical Floor Treatments (Hardeners)

As concrete wears down it is ground into dust and a great deal of trouble has been encountered with cement finished floors where the wearing and grinding process has been in progress. This condition has had an especially detrimental effect in mills and factories where the dust from the floors has been carried into the bearings of machinery, motors, engines, etc., causing considerable damage and expense in the upkeep of the equipment.

To overcome this condition, there have been a number of

chemicals in liquid form placed on the market that create a chemical action in the cement and lime in the floors and cause a complete transformation of the lime so that it solidifies the entire concrete aggregate into a hard, flint-like, homogenous mass that prevents dusting and wearing of the floors.

These liquid chemical compounds are swept over the floor until all of the pores in the surface are filled. It is usually necessary to treat the floors two or three times with the liquid to secure satisfactory results. When using these preparations, it is necessary to treat the floors with them at stated intervals, as the chemical action they create on the cement and lime is not permanent, although some manufacturers claim their product is permanent.

When using these liquid chemicals care must be exercised to see that the floor is absolutely clean and free from all grease, dust, dirt, oil, or other foreign matter.

The compounds are usually applied to the floor and spread with a long handled brush having stiff bristles. The floor should be thoroughly scrubbed and should be permitted to absorb as much of the liquid as possible, as it is by penetrating the surface of the floor that the chemical reaction takes place and hardens and densifies the surface.

Different manufacturers specify varying numbers of applications of their materials but all of them must be applied just as often as the floor shows signs of dusting.

Liquid Chemical Floor Hardeners

Kind of Hardener	No. Coats	Sq. Ft. per Gal.	Gals. Reqd. 100 Sq. Ft.	Price per Gal.	Labor Hours
Granitex, Devoe Paint	2	100	1	$4.59	0.8
Hornolith	3	150	1	2.55	0.8
Lapidolith	3	100	1	2.95	1.0
R.I.W. Flintox	2	125	¾	2.00	0.8

Labor Cleaning Floors.—The labor cost of cleaning floors is a matter that is entirely up to the judgment of the contractor or estimator. Floors that are full of oil and grease will require much more time to clean than a floor free of foreign matter.

The labor applying the liquid is also a variable item, but a man should scrub 200 sq. ft. of floor an hr. on the first application and 350 to 400 sq. ft. an hr. on subsequent applications.

The labor applying the first coat should cost as follows per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.5	$.....	$.....	$5.00	$2.50
Cost per sq. ft.					.025

On the second and third applications, the labor per 100 sq. ft. should cost as follows:

	Hours	Rate	Total	Rate	Total
Labor	0.3	$.....	$.....	$5.00	$1.50
Cost per sq. ft.					.015

Chemical Floor Hardener Crystals

Furnished in crystal form, requiring only the addition of water. Applied in the same manner as described above.

Chemical Floor Hardener Crystals

Kind of Hardener	No. Coats	Sq. Ft. per Lb.	Lbs. Reqd. 100 Sq. Ft.	Price per Lb.	Labor Hours
Agatex, Devoe Paint	2	45–50	2	$0.39	0.8
Hornstone	3	75	1⅓	.65	0.8
M.B. Saniseal	2	45–50	2	.77	0.8
Sika Hardener	2	50–70	1½–2	.45	0.8

Liquid Chemical Floor Hardeners Mixed in the Topping.—Liquid hardeners are mixed with the cement topping to harden and densify the concrete wearing surface and is recommended for new work because when mixed in the topping the chemical acts on the entire thickness of the finish top.

Usually one quart of liquid hardener is added to each sack of cement.

It requires 3 sacks of portland cement and 6 cu. ft. of sand to make sufficient topping for 100 sq. ft. of floor ¾-in. thick.

Integral Liquid Chemical Floor Hardeners

Name of Material	Quan. Reqd. per Sack Cement	Quan Reqd. 100 Sq. Ft. ¾" Top	Approximate Price per Gallon
Anti-Hydro	1 qt.	¾ gal.	$1.70
Dehydratine No. 80	1 qt.	¾ gal.	0.80
Plastiment	½–1 lb.	3 lbs.	.26
Sikacrete	1 qt.	¾ gal.	.80
Trimix	1 qt.	¾ gal.	1.28

Concrete Accelerators and Densifiers

There are numerous preparations on the market for controlling the set of concrete, increasing its early strength, densifying and waterproofing the concrete mass, and for preventing freezing during winter weather by lowering the freezing point of the mixing water.

The quantities given on the following pages were furnished by the manufacturers.

Anti-Hydro Accelerator and Anti-Freeze.—Can be mixed with the water or added to the wet mix. As a general rule, the standard proportion of 1.5 gals. of Anti-Hydro per cu. yd. of concrete, with reduced water content to compensate for increased slump, will give protection down to 23° F. on concrete deposited in forms except in the most exposed locations.

For cold weather work, be sure that sand and aggregate are free of ice.

To protect concrete or mortar against freezing, use the following table for anticipated outside air temperatures as follows:

32° to 25° F. use 1 part Anti-Hydro to 12 parts water.
25° to 15° F. use 1 part Anti-Hydro to 10 parts water.
15° or less, mechanical heat is necessary.

Price $1.70 gallon.

Calcium Chloride.—A white, dry, flaky chemical which, when added to the mixing water accelerates the initial hardening of concrete; at the same time densifies the concrete, making it more waterproof; reduces the freezing point of water, thereby aiding the fresh concrete to resist freezing in low temperatures.

Flake calcium chloride may be added to the mix in either dry form (as it comes from the package) or in the form of a solu-

tion. The solution is made up of flake calcium and water in proportions that will result in a liquid each quart of which will be equivalent to one lb. of 77-80% flake calcium chloride. One quart of standard solution can be substituted wherever one lb. of flake material is specified.

Calcium chloride is always added to the mix in terms of "pounds per sack of portland cement." The quantities recommended vary from one pound per sack of cement for use when the temperature is above 90° F. to as much as four pounds per sack of cement during the lower range of temperatures. Maximum efficiency is obtained in the use of up to two pounds the proportional reaction of quantities in excess of this amount being less marked. The use of quantities in excess of four pounds per sack of cement is not recommended at any time.

When dry flake calcium chloride is used it should be added to and with the aggregate and not the cement. When solution is used it should be introduced with the mixing water (which should in all cases be reduced by at least the amount of calcium chloride solution used).

The following quantities are recommended per sack of portland cement:

For temperatures above 90° F.....1 lb.
For temperatures 80° to 90° F. .....1.5 lbs.
For temperatures 32° to 80° F. .....2 lbs.
For temperatures below 32° F. .....2 to 4 lbs.,

depending upon prevailing temperature conditions and amount of protection furnished.

Calcium chloride costs approximately 3 to 4 cts. per lb. east of the Mississippi River—in the far west the cost is slightly higher.

M. B. Hi-Early Pozzolith.—An accelerator and water-reducing agent that permits up to 20 percent water reduction while increasing plasticity and reducing permeability and shrinkage. Where early form removal or high early strengths are important, concrete made with Hi-Early pozzolith provides 3 day normal strength in 1 day, 7 day normal strength in 3 days, 28 day normal strength in 7 days and 125 percent normal strength in 28 days and thereafter.

Use ½ lb. per sack of cement. Price, 30 cts. lb.

Plastiment (Sika).—Plastiment is a powder added in the proportion of ½ to 1-lb. per sack of cement. It will increase workability, density, surface hardness and decrease shrinkage. It may be used for concrete or mortar. Price 18 cts. per lb. in 50-lb. sacks.

Also available in a concentrated liquid form for use with automatic dispensing equipment. Use 2 to 4 fl. oz. per sack of cement. Price, $4.20 gal. in 55-gal. drums.

Dehydratine No. 80.—Liquid integral cement floor hardener, accelerator and anti-freeze compound. Used in the proportions of 1 quart per sack of cement. Price per gallon, $0.80 in drums.

Sikacrete.—Accelerating and plasticizing liquid for concrete or mortar, used as anti-freeze or rapid hardening compound. Used in the dilution of 1 part Sikacrete to 3 to 10 parts water. A dilution of 1 to 7 will reduce the hardening rate of mortar or concrete to one-half or protect against freezing to a temperature of 22° F.

Price $0.80 per gal. in drum lots.

Trimix.—A chemical solution of uniform strength which when used according to directions, functions as an accelerator, integral hardener or anti-freeze compound, for use in mortar or concrete work. As an anti-freeze, use as follows:

25° to 32° F., 1½ qts. Trimix to each sack of cement.

20° to 24° F., 2 qts. Trimix to each sack of cement.

15° to 19° F., 2½ qts. Trimix to each sack of cement.

Below 15° F., heat is necessary.

Price $1.28 per gal.

BONDING OLD AND NEW CONCRETE

The problem of bonding new concrete to old so the new concrete will remain permanently in place, is one that has received considerable attention among users of concrete. Unless the utmost care is exercised in preparing the old surface, the new concrete will invariably come loose where it is joined to the old concrete.

Different methods have been used to overcome this fault, but the basic condition of all of them is that the old surface must be thoroughly cleaned and washed, and the old aggregate must be exposed, which means that the thin film of cement that covers the surface of the concrete must be removed. One of the methods of preparing the old surface consists of hacking or picking it, and then washing or turning a steam hose under pressure to remove all dust and dirt from the old floor so as to present a perfectly clean surface.

Another method is to wash the concrete surface with a solution of muriatic acid and water to remove the old film of cement and then thoroughly wash the surface with clear water. After this has been done, the old concrete surface should be given a slush coat of neat portland cement and water, and the new concrete applied.

Hacking and Chipping Old Concrete.—The cost of hacking and chipping old concrete surfaces in preparation for bonding new concrete to old, is a variable item, depending upon the hardness of the old concrete and the condition of the surface. Under average conditions, a laborer using a pick, should hack and roughen 175 to 200 sq. ft. of "green" concrete floor per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	4	$.....	$.....	$5.00	$20.00
Cost per sq. ft.			.....		.200

Where the concrete floors are of old concrete, a man using hand tools will do well to hack and roughen 8 to 10 sq. ft. an hour, and even when a compressor and jack-hammer or bush-hammering tool is used it is often possible to hack and roughen only 20 to 25 sq. ft. an hr. and the cost per 100 sq. ft. should average as follows:

	Hours	Rate	Total	Rate	Total
Compressor expense	2.25	$.....	$.....	$4.00	$ 9.00
Compressor engineer*	2.25	.....	.....	6.00	13.50
Labor on jack-hammer	4.50	.....	.....	5.25	23.63
Cost per 100 sq. ft.	6.75		$.....		$46.13
Cost per sq. ft.			.....		.461

*Add only if required.

Anti-Hydro Bonding Coat.—Rough and clean the old concrete as previously described. Apply a coat of grout composed of ½ to ¾-sack of portland cement added gradually into a solution of 1-gal. of Anti-Hydro in 3 gals. of water until a thick, creamy consistency is obtained. After applying this grout to the prepared surface, the concrete or mortar should be placed while the grout is still wet.

Sufficient Anti-Hydro grout to cover 100 sq. ft. should cost as follows:

	Rate	Total	Rate	Total
0.25 gal. Anti-Hydro.....	$.....	$.....	$1.70	$0.43
0.25 sack portland cement.	.....	.....	1.80	.45
Cost per 100 sq. ft.....		$.....		$0.88
Cost per sq. ft.....		.....		.009

Daraweld-C (W. R. Grace Co.)—Daraweld-C is an emulsion of special internally plasticized high polymer resins uniformly dispersed in water. Mixed with cement mortars or grouts, it forms a durable, highly water-resistant bond. A Daraweld-C bond withstands water immersion without softening or disintegrating, resists the action of heat, cold, oil and gasoline, most acids and other corrosive materials. Its coupling action is so great that grouts containing Daraweld-C will bond not only to concrete and masonry, but to tile, wood, steel -even glass. Ready-to-use, non-settling, Daraweld-C will not re-emulsify when subjected to moisture. It is completely compatible with mixes containing calcium chloride.

Daraweld-C is used as a bonding agent admixture in grouts and mortars made from portland or Lumnite cement—assures their lasting adhesion to existing concrete. Formulated for exterior or interior use, it is especially useful for patching concrete floors, repairing cracks in walls, securing an integral bond between successive concrete pours, for waterproofing exteriors below and above grade, in Gunite applications, in bonding concrete to asphalt surfaces. Diluted with water, Daraweld-C is an excellent brush-on sealer for dustproofing concrete floors, and as a primer for painting concrete masonry.

Price is approximately $8.50 per gal.

M. B. Embeco.—A slush or bond coating material to insure a firm bond between old and new concrete. Roughen and thoroughly saturate the old concrete with water for 24 hours prior to placing new concrete. Mix 1 part Embeco and 1 part cement with sufficient water to produce a creamy consistency, then scrub into surface of the old concrete with stiff bristle brush. Place new concrete before bonding coat dries.

Requires approximately 15 lbs. per 100 sq. ft. Price, 11.5 to 9.5 cts. lb. depending upon quantity.

R. I. W. Toxement Bonding Coat.—This is composed of R. I. W. Toxement and neat portland cement.

One sack of portland cement and 5 lbs. of Toxement made

into a cement wash in accordance with specifications will cover about 800 sq. ft. of surface, at the following cost per 100 sq. ft.:

	Rate	Total	Rate	Total
⅝ lb. Toxement	$.....	$.....	$0.20	$0.13
12 lbs. portland cement	.....	.....	.019	.23
Cost per 100 sq. ft.		$.....		$0.36

Sika 1.—A liquid bonding for masonry surfaces. Mix Sika 1 (diluted with 10 parts of water) with one part portland cement and 2 parts sand and spatter on wall. Price $1.80 per gal.

Cement coats shall follow immediately after the bonding coat has been applied. Cement coats should contain Sikacrete, integral liquid compound.

Tremco Floor Bond.—A chemically treated metallic powder to use in bonding new concrete toppings to set slabs, where a perfect bond must be secured to prevent cracking.

Old surface must be roughened and cleaned as described on the previous page and the floor bond applied in 2 coats. Requires 25 lbs. of Metallic Floor Bond per 100 sq. ft. of surface. Price 34 cts. per lb.

When used for bonding vertical surfaces, 2 applications are required, using 15 lbs. of Floor Bond per 100 sq. ft.

Weld-Crete.*—A product that permanently bonds new concrete to old concrete, It also bonds new concrete to many other materials, such as brick, stucco, stone, etc.

For successful bonding of new concrete to old, the old concrete surface must be structurally sound and free from dust, dirt, loose material, grease, oil, wax, water soluble coatings, etc.

It is not necessary to chip, bush hammer or roughen the old surface in any way.

Weld-Crete may be used on either interior or exterior surfaces and may be applied over "green" concrete and damp or dry surfaces. May be applied with a brush, roller or spray. Spraying is most efficient and should be done with heavy industrial spray equipment.

Coverage, when sprayed, from 200 to 300 sq. ft. per gal. When brushed or rolled, coverage is somewhat less.

Price $9.00 per gal. in 55-gal. drums; $9.22 per gal. in 5-gal. pails.

Repairing Leaks Against Hydrostatic Pressure

When repairing leaks in basement walls or floors, tunnels,

*Larsen Products Corporation, Bethesda, Md.

pits, etc., where water pressure exists, the following methods and materials may be used.

Sika 2.—Sika 2, red, fast-setting, sealing liquid is mixed with standard portland cement in small quantities. It is used to plug infiltrations of water against high pressure. Sika 2 mortar will have an initial set of 15 seconds and a final set of 30 seconds. It is used after surrounding leaking concrete has been sealed with Sika 4A. Quantity required varies with degree of leakage. Price $6.00 to $8.30 per gal. depending upon quantity.

Sika 4A.—Sika 4A is a clear liquid mixed with neat portland cement in small quantities. The resulting mortar will have an initial set of less than 1 minute and a final set of approximately 5 minutes. Sika 4A may be diluted with water and the cement mixed with sand. This mortar is to be applied against damp surfaces or masonry over which water is running. If pressure is too heavy, bleeder pipes may be installed and after smaller leaks are sealed with Sika 4A, the bleeder holes may be plugged with Sika 2, liquid. Quantity required depends upon the degree of leakage. Price $4.00 to $5.00 per gallon, depending upon quantity.

CONCRETE ADMIXTURES

Since the introduction of the water-cement ratio law governing the strength and durability of concrete, the necessity for using comparatively low water ratio mixes has been generally recognized. Of greatest importance, however, has been the necessity of producing such mixes with a degree of workability which would insure their easy and economical placing and compacting.

In a cubic yard of concrete, approximately 2½ gallons of water per sack of cement are required to hydrate the cement. Any water in excess of that amount must be regarded as "placing" water, merely providing sufficient workability to make the mix placeable. This excess water occupies about 10 per cent of the total space in concrete. As it evaporates, it causes the concrete to shrink. Excess water also reduces the strength of the concrete.

The purpose of admixtures is to improve the plasticity, workability and finish of the concrete, to prevent segregation of the aggregates and to a certain extent provide integral waterproofing qualities by filling the small voids in the concrete mixture.

M. B. Pozzolith.—A water-reducing admixture which permits up to a 20 percent reduction in unit water content while maintaining the same workability or slump of a plain concrete mix.

Entrains 3 to 5 percent air without close field supervision. Its adaptations will entrain or detrain air to meet specific job requirements and will accelerate or retard setting time to meet finishing or form removal needs.

A dry powder, 1 lb. of Pozzolith is dissolved in sufficient water to make 1 gallon of solution. One quart of solution containing ¼-lb. of Pozzolith is used for each sack of cement in the mix.

Price, approximately 60 cts. lb.

Plastiment.—Plastiment, concrete densifier and retarding agent, is a powder to be added to concrete or mortar, using ½ to 1-lb. per sack of portland cement. For equal workability the water-cement ratio may be reduced approximately 10 percent. Results in better workability, density, adhesion to old concrete, surface hardness, and flexural and compressive strength. The delayed set results in elimination of cold joints and reduced shrinkage. Price 26 cts. per lb. in 50-lb. sacks.

Also available in a concentrated liquid form for use with automatic dispensing equipment. Use 2 to 4 fl. oz. per sack of cement.

Price, $4.20 gal. in 55-gal. drums.

Trimix (Sonneborn).—A multi-purpose concrete and mortar admixture which reduces water-cement ratio, produces higher early compression strengths, accelerates set and generally improves quality and workability of portland cement mixtures.

Used in the proportion of 1-qt. Trimix to each sack of cement in the mix. Price $1.28 per gal.

Hydrated Lime as a Concrete Admixture.—Hydrated lime is often used as an admixture to increase the plasticity and improve the workability of concrete. For this purpose 5 to 8 lbs. of hydrated lime are usually added to each bag of portland cement used in the concrete mixture. A gallon measure holds 5 lbs. and a 12-qt. pail holds 15 lbs. of hydrated lime.

Air Entraining Admixtures

In air entrained concrete 3 to 5 or 6 percent of air is incorporated in the concrete in the form of minute separated air bubbles. Such concrete is more resistant to freezing and thawing and to salt action than normal concrete. Originally developed to prevent scaling of pavement where salts are used for ice removal, air entrained concrete is being widely used for all types of work and in all locations because of its better workability as well as its better resistance to weathering even where salts are not used.

MB-VR.—MB-VR is a neutralized Vinsol resin type air entraining agent for concrete. It is furnished in water solution form and is ready to use as it comes from the drum. MB-VR is compatible for use with other admixtures commonly used in concrete;

however, if more than one admixture is used, each should be dispensed into the mix separately. MB-VR is packaged in 5 gal. steel pails and 55 gal. steel drums. Cost is $0.85 per gal. in 55 gal. drums.

Aerolith (Sonneborn).—A solution of neutralized vinsol resin. Renders concrete more resistant to exposure, improves workability, minimizes segregation, reduces bleeding and increases resistance of concrete to water absorption and to salts used in ice removal.

1 oz. of Aerolith per sack of cement added to the mixing water will entrain the required amount of air, that is 3 to 6 percent by volume. Price, $1.37 per gal.

Sika Aer.—Air entraining resin solution of neutralized wood resin improves various properties of plastic and hardened concrete.

Add between 1 and 2 ounces of Sika AER solution to entrain between 3 and 5 percent air as air content is in direct proportion to quantity of Sika AER added. Price $0.75 per gal. in 55-gal. drums.

Darex AEA (W. R. Grace Co.)—Darex AEA is an aqueous solution of highly purified and modified salts of a sulfonated hydrocarbon. It contains a catalyst which promotes more rapid and complete hydration of portland cement. Darex AEA is specifically formulated for use as an air entraining admixture for concrete and is manufactured under rigid control which insures uniform, predictable performance. The addition of ¾ fluid ounce of Darex AEA per sack of cement will generally entrain 4 to 7% air in an average (5½ sack) concrete mix.

The cost of Darex AEA is 90 cents per gal. in 55 gal. drums.

Waterproofing and Shrinkproofing Mortar

Considerable interest has been aroused as to the cause of leaky masonry walls and this has led to extensive investigation and tests by the National Bureau of Standards, Report BMS7, which investigated not only the materials such as brick, tile, concrete blocks, mortar, etc., but also the effects of different grades of workmanship.

After extensive tests, it was determined that workmanship affected the permeability of the walls more than any other factor. Walls with tooled joints were less permeable than similar walls with cut joints; but the quality of the workmanship inside the walls had a greater influence than the kind of surface finish on the joint. In other words, brick as laid on the average contract job, where mortar was spread and furrowed and the joints

not completely filled with mortar leaked far more than bricks laid in a full bed of mortar and "shoved" into position with full bed and head joints and a complete filling of joints between all brick.

It was also determined that nearly all of the leakage was through the mortar joints regardless of the kind of brick used and that in practically every instance where the "commercial" grade of workmanship was used, leaky walls resulted.

Where brick of high absorptive properties were used, the brick absorbed the water from the mortar, making it difficult to work and resulting in small hair cracks between the mortar joints and the brick. This also caused leakage through the walls.

The use of lime with low plasticity producing a mortar with low water retentivity greatly increased the permeability of the walls. This effect was more pronounced when the mortar was used with high absorptive brick.

Water reduction in cement and lime mortars is a highly desirable objective because with less water there is less evaporation and mortar shrinkage is reduced below the critical point.

Since these investigations have been made, numerous admixtures have been placed on the market to be added to the mortar mixture which are said to give the mortar greater plasticity, retain the water in the mortar, prevent shrinkage and leakage in the mortar joints and make a smoother mortar that will work better under the trowel.

Some of these products are listed on the following page:

Anti-Hydro.—Cement mortar for use with brick, block or stone shall be of 1:3 mix, gauged and tempered with a solution of 1 gal. Anti-Hydro to 15 gals. of water, or use 1 qt. Anti-Hydro to each sack of cement. Price $1.70 per gal.

Wet all brick. Push-lay and thoroughly grout all brick at every course. Parge with same mortar between the face brick and back-up masonry.

Aquatite.—Mortar to be composed of 1 part portland cement, 3 parts clean sand mixed with a solution of 1 part Aquatite to 15 parts water. Price $0.90 per gal.

Hydratite Plus.—A powder in concentrated form which when mixed with the mortar is dissolved and miscible in the water. It anchors the particle of water intimately to the particle of the cement, sand and lime with a bond greater than the suction of the brick. With less water it increases the flow or workability of the mortar.

Use 2-lbs. per sack of cement in 1:1:6 mortar. Price 18 cts. lb.

Hydrocide Powder.—When used for waterproofing masonry mortar, use 1-lb. of powder to each sack of cement or per cu. ft.

of lime putty used in the mixture. Price 19 cts. per lb.

M. B. Omicron Mortarproofing.—A plasticizing and water reducing agent that increases the workability of mortar, increases water retentivity and minimizes shrinkage. Contains stearate for increased water repellency. Add 1 lb. of Omicron for each sack of cement, lime or putty in the mortar mix.

Requires 5 to 6 lbs. per 1,000 brick, depending upon mortar proportions and width of joints. Price 16 cts. per lb.

Plastiment (Sika).—A powder used in the proportion of up to 1-lb. per sack of cement. Increases the workability of mortar, allows a reduction in the water-cement ratio, reduces bleeding and increases the bond between brick and mortar. Of particular advantage in hot weather construction as it delays the setting time and preserves the workability of the mortar for a longer time. Price 26 cts. per lb. in 50-lb. sacks.

R.I.W. Toxement.—R.I.W. Toxement powder, paste, concentrated paste or R.I.W. Toxmix liquid may be used for waterproofing and shrinkproofing masonry mortar. Description and prices on previous pages.

Sikacrete.—Accelerating and plasticizing liquid for use in brick mortar. Diluted with the gauging water 1 part Sikacrete to 3 to 7 parts water. Increases the bond and accelerates the hardening rate of mortar so that higher tiers of brick or glass block can be laid and the joints struck sooner. Price $0.80 per gal. in 55-gal. drums.

Emulsified Asphalt

Emulsified asphalt may be used as a floor surfacer, a bonding coat, or a quick-setting, hard-drying and durable patching material. It may be used with satisfactory results over either old or new floors. The following procedure is generally used. First, clean the old surface free from dirt, grease and foreign matter; second, cutting out the worn spots or cracks with perpendicular sides to avoid the formation of feather edges; third, a bonding coat of emulsified asphalt is applied, consisting of 1 part clean water to 4 parts of emulsified asphalt, dry overnight; fourth, the mixture of portland cement, sand, gravel and emulsified asphalt is applied and rolled.

When applied direct to a concrete surface, 1 gallon will cover about 75 sq. ft. one coat or 30 sq. ft. two coats.

When used instead of water as a material for binding cement, sand and gravel the quantity will vary with the thickness applied and will require 4 to 5 gallons per sack of cement.

Painting Concrete and Masonry Surfaces

Hydrocide Colorcoat (Sonneborn).—An alkyd-epoxy-silicone-oil base formula, decorative coating especially designed for exterior, highly porous surfaces. Properly applied, it effectively seals and protects such surfaces with a color-fast, decorative coating, which will not run or sag, in one application. It will fill pores and bridge hairline cracks on concrete or masonry surfaces which are completely cured.

One gallon of material, used as it comes in the container, will cover 60 to 75 sq. ft. depending upon porosity of the surface, to a thickness of 10 to 12 mils. Price, $6.76 per gal.

Hydrocide Super Colorcoat (Sonneborn).—Super Colorcoat is for use on cured, green, or slightly damp surfaces. It is a water-dispersed acrylic emulsion formulation. It is also mildew and fungus resistant and non-flammable.

Super Colorcoat will cover approximately 80 to 100 square feet per gal. Cost per gal. is $6.94.

Sika-Kote.—A cement base paint in powder form mixed with water. To be applied to concrete, stucco or other clean masonry surfaces on the inside or outside of buildings. Applied with a brush and a single coat is ordinarily required. Furnished in white only.

One gal. covers approximately 60 to 120 sq. ft. Price $2.60 per gal.

Concrete Curing Process

Efficient methods of curing concrete are of vital importance to every contractor because exposed surfaces such as concrete floors, roofs, road, pavements, airport runways, and other surfaces exposed to the sun, require protection during the curing period.

This was formerly accomplished by the use of damp burlap, sand, sawdust, dirt covering, paper or ponding.

A method that is being used to a large extent is the use of an efficient curing compound, which provides an air-tight seal over the surface of the concrete and prevents the evaporation of the water from the concrete until it has cured normally.

These compounds are usually applied with a brush or spray as soon as the concrete has set sufficiently to prevent injury.

Horncure (W. R. Grace Co.).—A transparent liquid formulated to produce a watertight, airtight seal on the concrete in one operation. Does not stain concrete and dries quickly and uniformly

without pinholes. Produces a membrane on the slab of concrete, retarding evaporation of the water necessary for proper hydration of the cement and curing. It is applied in one coat by spray immediately after the concrete is placed.

Covering capacity 270 to 350 sq. ft. per gal. Price $1.50 per gal. in 55-gal. drums.

R. I. W. Toxcure.—An elastic, waterproof, transparent medium for curing concrete floors, roads and walls.

One coat application is all that is required and may be applied with brush or spray. One gallon covers 250 to 350 sq. ft. Price $0.80 to $1.20 per gal., depending upon quantity.

Kure-N-Seal (Sonneborn).—Kure-N-Seal cures, seals and dustproofs in one application, and it increases surface hardness when applied as a curing membrane after final troweling. By locking in essential curing moisture the hydration process is refined and maximum hardness for the involved mix is assured.

Kure-N-Seal costs $3.87 per gal. in 55 gal. drums or $4.10 per gal. in 5 gal. pails.

CHAPTER XII

BRICK MASONRY, GLASS BLOCK

To prepare an accurate estimate on the cost of brick masonry requires a knowledge of the various factors entering into the work. This includes the type of building, thickness of walls, kind of mortar, style of mortar joint, class of workmanship, ability of workmen, and last but not least, the ability of the foreman in charge.

Estimating brickwork is more than a matter of referring to a table or chart to obtain the prevailing wage scale and from that determine the labor cost of laying a thousand brick. If accuracy is important in the preparation of your estimates then all of the above items should be considered when determining the unit costs. If this were not so, any inexperienced person could become an expert estimator in a week's time.

The type of building plays an important part in the costs because a mason can lay far more brick on a factory or warehouse building having long straight walls than on a school or office building, cut up with numerous windows, which require straight walls, plumb jambs, pilasters, etc.

A mason can lay far more brick on a 16" wall than on an 8" wall and he can lay more brick in smooth working lime mortar than in coarse portland cement mortar. He can also lay more brick by merely cutting the mortar joints than by striking them with the point of his trowel.

The class of workmanship plays an important part. Many of the cheaper constructed speculative buildings have crooked walls, open mortar joints and present an all round slovenly appearance, while the best grade of workmanship requires full mortar joints, straight walls, plumb jambs, and corners, etc.—in other words, good workmanship.

Weather conditions also affect labor costs. A mason can lay more brick on a clear, dry day than when it is cold and wet, or when it is necessary to heat materials during freezing weather.

The demand for mechanics also affects their output. When there is an abundance of work, some (not all) mechanics take advantage of this condition and do just as little work as possible to hold their jobs. On the other hand, when work

is scarce and there are two mechanics for every available job, they do a much better day's work when they know there is another man eagerly waiting to take his place.

The ability of the foreman in charge of the work has much to do with the final costs; his ability to plan, schedule and lay out his work in addition to obtaining a full day's work from the men under his supervision are equally important.

If accurate costs are to result, then all of these matters should be considered when making up your estimate.

Masonry Specifications

The estimator in preparing his proposals from architectural plans and specifications will most generally today find units referred to by specifications published by the American Society for Testing and Materials. These specifications set limitations on requirements and properties of the various materials and these are generally accepted by manufacturers.

ASTM specifications are available for all the following materials which the mason may encounter:

C 216-66	Facing brick, clay or shale
C 62-66	Building brick, clay or shale
C 73-67	Building brick, sand-lime
C 126-67	Ceramic facing brick and tile
C 410-60	Industrial floor brick
C 279-54	Chemical resistant masonry units
C 7-42	Paving brick
C 32-63	Sewer brick, clay or shale
C 270-64T	Mortar for unit masonry
C 476-63	Mortar and grout for reinforced masonry
C 466-64	Chemically setting silicate and silica types of chemical-resistant mortars
C 395-64	Resin type chemical-resistant mortars
C 287-67	Sulphur mortar

While every estimator should have a general acquaintance with all the above specifications, he will deal primarily with face brick, building (formerly called common) brick and mortar for unit masonry. Building brick is subdivided into 3 grades: SW, MW, and NW, indicating severe, medium and negligible weathering. Face brick is subdivided into only SW and MW grades, but these grades each have 3 types: FBX, FBS, and FBA, which set forth requirements as to appearance and size.

Mortar specifications cover both portland cement-lime and masonry cement mortars and are subdivided into types M, S, N, O

and K, based on 28 day compressive strengths of 2,500, 1,800, 750, 350 and 75 lbs. per sq. in. ASTM specifications are also published for all the manufactured ingredients for the mortar.

An estimator should welcome a specification based on these ASTM designations as they enable him to figure within well defined limits and he might do well to adopt their terminology in proposals he submits.

Mortar Materials

Cements. Type I portland cement is the basic cement used in most mortars. Type II, for use where sulphate action is a problem, and Type III, a high early strength cement, are also included under ASTM specifications for mortar C 270-64T.

Air entraining cements should usually not be substituted, as bond strength is affected. Full information on tests and specifications are available in ASTM publications and in information published by the Portland Cement Association.

Masonry cements are included in ASTM specifications, but their chemical makeup is not regulated and varies widely among the manufacturers. It may therefore take some experimentation to find the product most suited to the job.

Masonry cements do, however, contain additives that increase workability and water retentivity, and the single product saves handling both portland cement and lime on the job, and mortar can be used as soon as mixed—all advantages. However, where a Type S mortar is selected for bonding strength, care should be taken not to select a masonry cement with air entrainment properties. Masonry cements are marketed under such names as Brixment, Atlas, Lehigh, Hy-Test, Medusa-Brisket, etc.

Lime.—Lime for construction purposes is available in both the quick (unslaked) and hydrated (slaked) forms, though in recent years hydrated lime has been preferred to quicklime because it is faster, easier, and safer to use. Building lime is supplied in bulk or packaged in 50-lb. multiple-wall, moisture resistant bags. Barrels, once widely used to package lime, are no longer in use as containers for domestic lime shipments. Lime products sold in bulk or bags are generally quoted on a ton (2000 lbs. net) basis.

Quicklime may be purchased in the following forms, the principal difference being in the size of the particles: pebble lime, crushed lime, ground lime, and pulverized lime. All quicklime must be slaked prior to use and manufacturers' directions for slaking should be followed to secure best results. Due to the greater ease with which complete slaking is secured, the finer divided types of quicklime are preferred. Since quicklime is

very reactive with water, care should be exercised at all times during the slaking operation to prevent splattering of the lime and potentially serious burns of the eyes and skin. Slaked quicklime putty should be screened and permitted to age until all the lime particles are completely slaked. The aging period may vary from a few hours to several days according to the chemical and physical properties of the quicklime employed and the skill of the operator in slaking the lime.

Hydrated lime for structural use is furnished in the dry powdered form usually packaged in 50 lb. net paper bags and sold by the ton (2000 lbs. net). It may also be purchased in bulk if proper facilities are available for handling and storage. In recent years a new special type of hydrated lime has been marketed known as Type "S" or pressure hydrated lime. This highly hydrated product contains a maximum of 8% combined unhydrated calcium and magnesium oxides; in addition putties made from this lime develop high plasticities instantly upon mixing. Type "S" hydrated limes meeting all ASTM requirements are commercially available in both the dolomitic and high calcium varieties. Type "N" (normal) hydrated limes should be soaked in a paste or putty form for several hours or overnight prior to use in order to enhance their plasticity and workability. The preferred method for soaking is to sift the hydrated lime evenly into a watertight box or vat which has been previously half filled with clean water. Do not stir, mix, or agitate the mass, but allow the lime to settle naturally; continue to add the hydrate slowly and evenly over the entire surface of the water until a thick paste is formed after which the mass is permitted to soak until required for use.

All building limes should comply with the requirements of the Standard Specifications for Hydrated Lime for Masonry Purposes (C-207-49) or Quicklime for Structural Purposes (C-5-59) as adopted by the American Society for Testing Materials.

Storage of Lime and Lime Putty.—Prior to slaking, or use, all quicklime and hydrated lime previously delivered to the site of the work should be stored in a clean, dry place.

Quicklime is shipped in bulk and waterproofed multi-wall paper bags. When furnished in bulk, it should be slaked immediately to assure maximum putty yield and avoid loss. Quicklime furnished in bags may be stored for considerable time depending upon the humidity and storage conditions.

Hydrated lime in bulk or packed in bags may be stored for relatively long periods of time provided it is placed in a clean, dry, properly ventilated warehouse.

Lime putty should be aged and stored in clean, tight vats and

should be well protected from direct contact with the atmosphere by maintaining a thin film of water over the surface.

Commercial plants for the production of scientifically prepared, well aged putty, are in operation in many markets. The use of commercially prepared lime putty eliminates all necessity for slaking and aging or soaking of lime on the job, and has the further advantage of providing the estimator with reliable figures for estimating purposes since purchase order is based on net quantity of lime putty required for the operation. Other advantages of commercially produced lime putty include flexibility during construction, eliminating lost time awaiting preparation of lime putty and admitting of expansion in operations on short notice, reduction in storage space required for materials at the site of the work and improved quality of putty due to careful supervision during slaking and aging of lime putty.

Lime Putty and Its Preparation.—Job specifications generally require mortar to be mixed in definite predetermined proportions by volume and the lime proportion is usually determined in volumes of lime putty, therefore, some knowledge of putty yield of lime is necessary in preparing estimates of quantity of lime required. The putty yield of different limes varies over a relatively wide range according to chemical and physical properties of the lime, methods of processing etc. However, the quantities given in the following table may be used as a sound, conservative average for estimating purposes.

Quantity of Lime Putty Obtainable from Various Types of Lime

Type of Lime	Average Cu. Ft. Putty per ton of lime	No. Lbs. Lime per Cu. Ft. Putty
Hydrated Lime	46 cu. ft.	25
Pebble or Pulverized Quicklime	80 cu. ft.	44

109 lbs. portland cement produces 1 cu. ft. of cement paste of normal working consistency.

9 cu. ft. of putty or paste with 27 cu. ft. of ordinary building sand will produce 1 cu. yd. of 1:3 mortar

Quantity of Materials Required for Masonry Mortar Using Pebble or Pulverized Quicklime at 80 cu. ft. Lime Putty per Ton

Proportions by Volume			Quantity of Materials Required					
			For one cu. yd. mortar			To lay 1000 brick (18 cu. ft.)		
Lime Putty	Portland Cement	Sand	Lime† Pounds	Cement Sacks	Sand Cu. Yd.	Lime† Pounds	Cement Sacks	Sand Cu. Yd.
1	0	3	225	0	1	150	0	.67
3	1	12	169	2.25	1	113	1.50	.67
2	1	9	150	3	1	100	2.00	.67
1½	1	7.5	135	3.6	1	90	2.40	.67

(Continued on next page)

Proportions by Volume			Quantity of Materials Required For one cu.yd. mortar			To lay 1000 brick (18 cu.ft.)		
Lime Putty	Portland Cement	Sand	Lime† Pounds	Cement Sacks	Sand Cu. Yd.	Lime† Pounds	Cement Sacks	Sand Cu. Yd.
1	1	6	112.5	4.5	1	75	3.00	.67
½	1	4.5	75	6	1	50	4.00	.67
0	1	3	0	9	1	0	6.00	.67
*10%	1	3	22.5	9	1	15	6.00	.67
*15%	1	3	34	9	1	23	6.00	.67

*Based on volume of cement required. Add 5 to 10 percent to the above quantities for waste.
†Dry unslaked lime.

Quantity of Materials Required for Masonry Mortar Using Hydrated Lime at 46 cu. ft. Lime Putty per Ton

Proportions by Volume			Quantity of Materials Required For one cu.yd. mortar			To lay 1000 brick (18 cu.ft.)		
Lime Putty	Portland Cement	Sand	Lime Pounds	Cement Sacks	Sand Cu. Yd.	Lime Pounds	Cement Sacks	Sand Cu. Yd.
1	0	3	391	0	1	261	0	.67
3	1	12	293.5	2.25	1	196	1.50	.67
2	1	9	261	3	1	174	2.00	.67
1½	1	7.5	235	3.6	1	157	2.40	.67
1	1	6	195.5	4.5	1	130	3.00	.67
½	1	4.5	130.5	6	1	87	4.00	.67
0	1	3	0	9	1	0	6.00	.67
*10%	1	3	39	9	1	26	6.00	.67
*15%	1	3	59	9	1	39	6.00	.67

*Based on volume of cement required. Add 5 to 10 percent to the above quantities for waste.

Where hydrated lime is used in dry powdered form it is usually assumed that a given volume of dry hydrated lime will produce an equivalent volume of lime putty, thus a bag of dry hydrated lime (50 lbs. net) is equivalent to approximately 1.15 cu. ft. of lime putty.

Labor Slaking Lime and Making Mortar.—When mixing mortar by hand, a good mortar maker should slake and sand about a ton of quicklime per 8-hr. day, and should make about 4 cu. yds. of mortar per 8-hr. day.

The actual labor cost of making 18 cu. ft. of mortar, sufficient for 1,000 common brick, should average as follows:

	Hours	Rate	Total	Rate	Total
Mortar maker.....	1.33	$.....	$.....	$5.00	$6.65

On jobs using common brick only, a mortar maker should slake lime and make sufficient mortar to supply 7 to 9 masons, depending upon thickness of joints, width of walls, etc.

On an average job consisting of 4" of face brick backed up with 8" to 12" of common brick, a good mortar maker should supply 10 masons without difficulty.

On face brick work alone, a mortar maker should supply 16 to 24 masons with mortar, depending upon the class of work and the width of the mortar joints.

On practically all jobs of any size today, the mortar is mixed in a mixer as it produces a more uniform mortar and one that is more easily spread. It not only enables a mason to lay more brick but also results in a saving of 10 to 20 percent in labor required mixing mortar.

Quik-Slak Masons Lime.—A lime furnished in pulverized form that slaks the instant it hits the water. Put up in 50 lb. paper sacks and the manufacturers say that 4 sacks are sufficient to lay 1,000 brick under average conditions. Price is $1.00 per bag.

Aggregate.—Aggregate may be either natural sand that is clean and sharp or sand manufactured by crushing stone, gravel or air-cooled iron blast furnace slag. Sand should be properly graded as set forth in ASTM Specification C 144-66T, with all sand passing a No. 4 sieve and approximately 10% passing a No. 200 sieve. Too coarse a sand decreases workability while too fine a sand decreases water retentivity.

Mortar Colors.—Mortar coloring agents may be added, either natural, such as white sand, or pigments, such as those manufactured by the Ricketson Color Corporation. While different color effects will require some experimentation, in general, one bag of color to one bag of cement, hydrated lime or cu. ft. of putty and 3 cu. ft. of sand can be figured, or 5 to 6 bags per 1,000 bricks with a ½" joint.

Color should be mixed with the dry cement in order to produce uniform color. Freshly slaked lime should be allowed to cool 48 hrs. before adding color. Do not rake joints until mortar has begun to set. Avoid a sloppy mortar.

Packed 6 bags to each carton, weighing from 15 to 32 lbs. per carton depending upon the shade, sufficient to lay approximately 1,000 brick with ½" mortar joints.

Color	Weight per Carton	Price per Carton	Color	Weight per Carton	Price per Carton
Red	24 lbs.	$3.50	Chocolate	30 lbs.	$4.50
Light Buff	20 lbs.	4.50	Black	15 lbs.	5.50
Dark Buff	30 lbs.	4.60	Green	12 lbs.	6.50
Pompeian Buff	18 lbs.	4.60			

Types of Mortar

The following mortars are based on proportion set forth in ASTM specifications. These mortars were designated Type A-1, A-2, B and C prior to 1954.

Type M mortar is a high strength mortar used primarily in foundation masonry, retaining walls, walks, sewers and manholes. Its proportions and costs for a cement-lime mixture are:

1 cu. ft. portland cement	$1.80
¼ cu. ft. lime @ $0.87 per cu. ft.	.22
3 cu. ft. sand @ $0.15 per cu. ft.	.45
	$2.47 or $0.8233 per cu. ft.

Proportions and costs for a Type M mortar using masonry cement are:

1 bag portland cement	$1.80
1 bag Type II masonry cement	1.40
6 cu. ft. sand @ $0.15 per cu. ft.	.90
	$4.10 or $0.6833 per cu. ft.

Type S mortar also has a reasonably high compressive strength and develops maximum tensile bond strength between brick and cement-lime mortars. It is recommended for use in reinforced masonry and where flexural strengths are required, such as cavity walls exposed to strong winds, and for maximum bonding power, such as for ceramic veneers. Proportions and costs for cement-lime Type S mixtures are:

1 cu. ft. portland cement	$1.80
½ cu. ft. lime @ $0.87 per cu. ft.	.42
4½ cu. ft. sand @ $0.15 per cu. ft.	.675
	$2.895 or $0.6433 per cu. ft.

Costs and proportions for cement masonry Type S Mortar are:

½ bag portland cement	$0.90
1 bag masonry cement	1.40
4½ cu. ft. sand @ $0.15 per cu. ft.	.675
	$2.975 or $0.66 per cu. ft.

Type N mortar is a medium strength mortar most generally used

in exposed masonry above grade. The proportions and cost of Type N cement-lime mortar is:

1 cu. ft. portland cement	$1.80
1 cu. ft. lime	.87
6 cu. ft. sand @ $0.15 per cu. ft.	.90
	$3.57 or $0.595 per cu. ft.

Proportions and cost of Type N masonry cement mortar is:

1 cu. ft. masonry cement	$1.40
3 cu. ft. sand @ $0.15 per cu. ft.	.45
	$1.85 or $0.616 per cu. ft.

Type O mortar is a low strength mixture for general interior use where compressive strengths do not exceed 100 psi. It may be used elsewhere where exposures are not severe and no freezing will be encountered. Proportions and costs of Type O cement-lime mortar is:

1 cu. ft. portland cement	$1.80
2 cu. ft. of lime @ $0.87 per cu. ft.	1.74
9 cu. ft. sand @ $0.15 per cu. ft.	1.35
	$4.89 or $0.5433 per cu. ft.

Proportions and cost of Type O masonry cement mortar is:

1 cu. ft. masonry cement	$1.40
3 cu. ft. sand @ $0.15 per cu. ft.	.45
	$1.85 or $0.616 per cu. ft.

In the above costs lime is figured in an exact proportion. As noted above under "Quantity of Materials Required for Masonry Mortar Using Hydrated Lime . . .", a 50 lb. bag of hydrated lime will make 1.15 cu. ft. putty. The ASTM specifications for Types N and O mortar allow some leeway in lime proportions and a full bag of lime can be figured. Only with very high strength mortars might you have to figure splitting bags to achieve exact proportions.

Cu. Ft. of Mortar Required to Lay 1,000 Face Brick

Based on standard size brick having ¼" to ⅜" end joints and "bed" joints as follows:

Width of Mortar Joints in Inches

1/8"	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"
4	7	9	12	14	16	18	20

For Dutch, English and Flemish Bond, add about 10 percent to the above quantities on account of additional head joints.

Labor cost to mix mortars is usually figured as part of labor cost setting brickwork. However, if figured separately, it will run about $0.20 per cu. ft. Most mortar is machine mixed and an additional $0.05 per cu. ft. of mortar should cover that cost, depending on rental cost and how effectively the machine is used.

Selecting Mortars. Often the estimator will have no choice in the makeup of his mortar, the architect's specifications setting forth exactly what is required. As replacing masonry that is found not acceptable by an architect or owner is extremely expensive, it is false economy indeed to alter specifications without approval of the architect, not to mention the loss of reputation involved.

However, many jobs will leave considerable leeway in the selection of mortars and an informed estimator may even perform a valuable service in suggesting changes to the mortar proportions that will either save money or make a better job. All too often a mortar may be selected on the basis of high compressive strength when the job may require only a 100 psi. This is not only wasteful of cement, but such mortars do not have the adhesive and sealing powers of the weaker mortars, and these two characteristics are the primary functions required on most jobs.

Of further importance to the estimator is the workability of the mortar which will enable the bricklayer to lay more units. A complete discussion of mortars and recommendations is contained in Chapter 4 of "Brick and Tile Engineering" by Harry C. Plummer, published by Structural Clay Products Institute, Washington, D.C. It is highy recommended.

Types of Brick Walls

The Structural Clay Products Institute separates brick walls into 3 general categories: conventional, bonded walls; drainage type walls; and barrier type walls.

The drainage type walls include brick veneer, the "SCR brick" wall, the cavity type wall, and the masonry bonded hollow wall. Drainage type walls are recommended for walls subjected to the most severe exposures. The success of this type of wall, of course, depends on the care taken to provide continuous means for water to escape.

The barrier type walls include metal tied walls and reinforced

brick masonry. The success of these walls will depend on a solidly filled collar joint. The SCR presently recommends using an 8" metal tied wall in preference to an 8" bonded wall for areas subjected to moderate exposure. Metal tied walls adapt well to brick and block or tile backup.

Bonded walls are still widely used and can be more interesting in design. Presently, there is renewed interest in interior masonry bearing walls, applied in some cases to high rise buildings. In Europe, buildings as high as 16 stories are being built with the full load of the structure carried on 8" walls. It is most often encountered in this country in apartment and dormitory type buildings of 3 to 4 stories high with many fixed interior partitions. In this type of construction, the compressive strength of the brick and mortar is of great importance.

When estimating the number of brick required for any job, obtain the length, height and thickness of each wall, stating the totals in cu. ft.

In present day estimating, all openings should be deducted in full, regardless of their size, as the estimate should show as accurately as possible the exact number of brick required for the job. The old method of counting corners twice, doubling the number of brick required for pilasters, chimney breasts, etc., is no longer used by progressive builders because they know they would never get a job using obsolete methods—and if they did get it, they would have no idea of the actual number of brick required to build it. Actual quantities and costs is the only sure method of getting your share of work at a profit.

Brick walls are usually designated on the plans as 4" or 4½"; 8" or 9"; 12" or 13"; 16" or 17", etc., increasing by 4" or 4½" in width. This variation in thickness need not be considered by the estimator because a wall marked 13" on the plans does not require any more brick than one marked 12", as both walls are 3 brick thick. A 4" or 4½" wall is 1 brick thick; an 8" or 9" wall is 2 brick thick; a 12" or 13" wall is 3 brick thick; a 16" or 17" wall is 4 brick thick, etc. The easiest method for the estimator is to mark all walls, 4", 8", 12", or 16" and then reduce the totals to cu. ft. After the number of cu. ft. has been obtained, multiply by the number of brick required per cu. ft. of wall and the result will be the number of brick required for the job.

When brickwork is estimated on the above basis, it is advisable to add 1½ to 2 percent to the total to take care of salmon brick, broken brick, bats, etc., and the waste should not exceed this amount unless very poor brick or poor job handling methods are used.

Many years ago contractors figured their building brickwork on the basis of 7 or 7½ brick per sq ft. of 4″ or 4½″ wall; 14 or 15 brick per sq. ft. of 8″ or 9″ wall; 21 or 22½ brick per sq. ft. of 12″ or 13″ wall, etc.

This method is no longer used by progressive contractors because modern business practice, sometimes called "competition" demands that actual quantities be figured. Work is being estimated too closely today to permit a 10 to 20 percent overrun on the brickwork, especially when many contractors are figuring on a 5 to 10 percent margin of profit.

After the number of cu. ft. of brickwork has been obtained it will be necessary to determine the number of brick required per cu. ft. of wall. This will vary with the size of the brick and the width of the mortar joints. The standard non-modular size is 8″x2¼″x3¾″. Modular brick is 7½″x2⅝″x3½″. Sizes will vary somewhat depending upon the burning, the brick in the center of the kiln usually being more thoroughly burned.

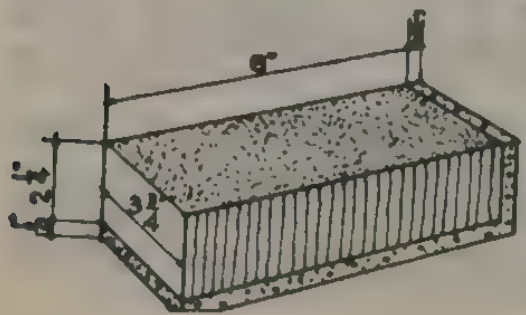
When estimating the number of face brick required for any job, obtain the length and height of all walls to be faced with press brick, and the total will be the number of sq. ft. of wall.

Always make deductions in full for all openings, regardless of their size, as the estimate should show as accurately as possible the exact number of brick required to complete the job.

When making deductions for door and window openings, always note the depth or width of the brick jambs or "reveals". If they are only 4″ deep, deduct the full size of the opening as the 4″ end of the brick forms the "reveal" or jamb.

If the jamb is more than 4″ wide, the full depth of the jamb or "reveal" should be deducted. Example: Deduct for a 5′-0″x 7′-0″ opening in a 12″ brick wall where the face brick jamb or "reveal" returns the full thickness of the wall. It will be necessary to deduct for the 12″ jamb or "reveal" on each side of the opening, i.e., 2x12″=24″ or 2′-0″. Deduct this from the width of the opening, i.e., 5′-0″—2′-0″=3′-0″. The opening deducted should be 3′-0″x7′-0″ instead of 5′-0″x7′-0″, as shown on the plan.

Standard Brick



A standard brick is 8″ long, 2¼″ high and contains 18 sq. in. on the face. If laid dry without a mortar joint it would require 8 brick per sq. ft. of wall (144÷18=8). However, the thickness of the mortar joint must be added, and this will

vary from $\frac{3}{8}$" to $\frac{5}{8}$", with $\frac{1}{2}$" the average width. A brick is 8" long, plus $\frac{1}{4}$" for the vertical or end mortar joint makes a total length of $8\frac{1}{4}$". A brick is $2\frac{1}{4}$" high, plus $\frac{1}{2}$" for horizontal or bed mortar joint, makes the total height of each brick course $2\frac{3}{4}$". $8\frac{1}{4}$"x$2\frac{3}{4}$"$=22\frac{11}{16}$ sq. in. on the face.

To obtain the number of brick required per sq. ft. of wall divide 144 by $22\frac{11}{16}$" and the result is 6.35 or $6\frac{1}{3}$ brick per sq. ft. of 4" or $4\frac{1}{2}$" wall. If the wall is 8" or 9" (2 brick) thick 2x$6\frac{1}{3}$=$12\frac{2}{3}$ brick per sq. ft. of 8" or 9" wall. If 12" or 13" (3 brick) thick, $6\frac{1}{3}$x3=19 brick per sq. ft. of wall, etc.

This same method should be used to obtain the number of brick of any size required for one sq. ft. of wall of any thickness.

Number of Standard Brick (8"x$2\frac{1}{4}$"x$3\frac{3}{4}$") Required for One Sq. Ft. of Brick Wall of any Thickness

Thickness of Wall	Number of Brick Thick	Vertical or End Mortar Joints figured as ¼" wide — Width of Horizontal or "Bed" Mortar Joints ⅛"	¼"	⅜"	½"	⅝"	¾"
4" or $4\frac{1}{2}$"	1	7.33	7	6.67	6.33	6.08	5.8
8" or 9"	2	14.67	14	13.33	12.67	12.17	11.6
*12" or 13"	3	22.00	21	20.00	19.00	18.25	17.4
16" or 17"	4	29.33	28	26.67	25.33	24.33	23.2
20" or 21"	5	36.67	35	33.33	31.67	30.42	29.0
24" or 25"	6	44.00	42	40.00	38.00	36.50	34.8

*Use this column for computing the number of brick required per cu. ft. of wall with any width mortar joint.

Mortar Required to Lay 1,000 Standard Brick.—The quantity of mortar required to lay 1,000 standard brick will vary with the width of the mortar joints and the thickness of the wall but the following quantities have been computed on a basis of 8"x$2\frac{1}{4}$"x$3\frac{3}{4}$" brick, having $\frac{1}{4}$" end and side joints and $\frac{1}{8}$" to $\frac{3}{4}$" bed joints, a total of 57 sq. in. of surface, plus 10 per cent for waste.

Thickness of Horizontal or "Bed" Mortar Joints ⅛"	¼"	⅜"	½"	⅝"	¾"
7 cu. ft.	$9\frac{1}{2}$ cu. ft.	$12\frac{1}{2}$ cu. ft.	15 cu. ft.	18 cu. ft.	20 cu. ft.

The quantities given for $\frac{1}{2}$" and $\frac{5}{8}$" joints are commonly used.

Cubic Feet of Mortar Required per Thousand Brick*

For various thicknesses of walls and joints. No allowance for waste.

*Quality Lime Institute, Philadelphia, Pa.

Joint Thickness	4" Wall	8" Wall	12" Wall	16" Wall	20" Wall	24" Wall
1/8"	2.9	5.6	6.5	7.1	7.3	7.5
1/4"	5.7	8.7	9.7	10.2	10.5	10.7
3/8"	8.7	11.8	12.9	13.4	13.7	14.0
1/2"	11.7	15.0	16.2	16.8	17.1	17.3
5/8"	14.8	18.3	19.5	20.1	20.5	20.7
3/4"	17.9	21.7	23.0	23.6	24.0	24.2
7/8"	21.1	25.1	26.5	27.1	27.5	27.8
1"	24.4	28.6	30.1	30.8	31.2	31.5

Variations in Face Brick Quantities.—If the brick are laid in running bond without headers, the above quantities will prove sufficient but if there is a full course of headers every 5th, 6th or 7th course, it will be necessary to allow for the extra brick required. Also, if the brick are laid in English, Flemish, English Cross or Dutch Bond, it will be necessary to make an allowance for extra brick where full header courses are required.

Number of Square Inches Occupied by One 8"x2¼" Face Brick With Various Width Mortar Joints

All Vertical Mortar Joints Figured ¼" Wide
Width of Horizontal or "Bed" Mortar Joints in Inches

1/8"	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"
19.30	20.625	21.656	22.69	23.72	24.75	25.78	26.81

Number of 8"x2¼"x3¾" Face Brick Required Per Sq. Ft. of Wall In Running Bond Without Headers

All Vertical Mortar Joints Figured ¼" Wide
Width of Horizontal or "Bed" Mortar Joints in Inches

1/8"	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"
7.46	7.0	6.65	6.35	6.08	5.82	5.60	5.38

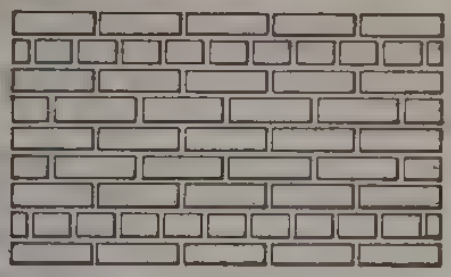
The above table does not include any allowance for waste, breakage, nor for header courses extending into the building brick backing to form a bond, but is based on using all stretchers or blind headers with metal wall ties.

On face brick work, 3 to 5 percent should be added to the net quantity for waste.

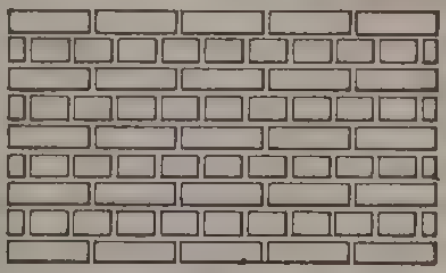
For face brick laid with a row of full "headers" every 5th, 6th or 7th course add the following percentages to the above quantities:

Percentages to be Added for Various Brick Bonds

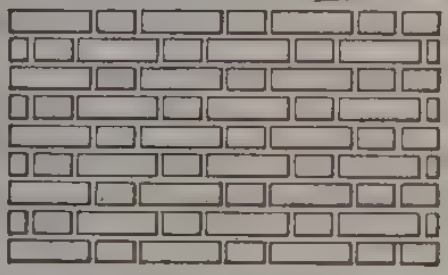
Common (full header course every 5th course).... 20 % or 1/5
Common (full header course every 6th course).... 16⅔% or 1/6
Common (full header course every 7th course).... 14⅓% or 1/7



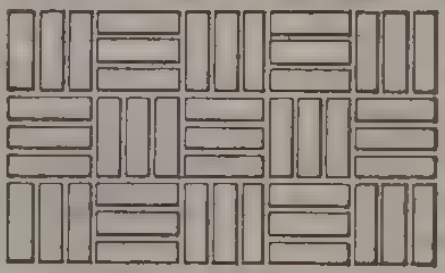
COMMON BOND
7.88 BRICK PER SQ FT.
(CONTINUOUS FULL HEADERS EVERY 6TH COURSE)



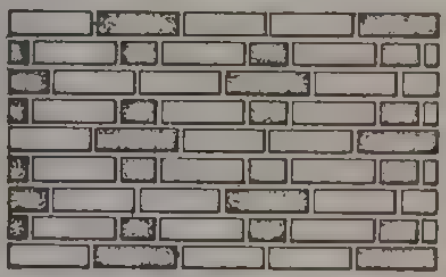
ENGLISH BOND
7.88 BRICK PER SQ FT.
(CONTINUOUS FULL HEADERS EVERY 6TH COURSE)



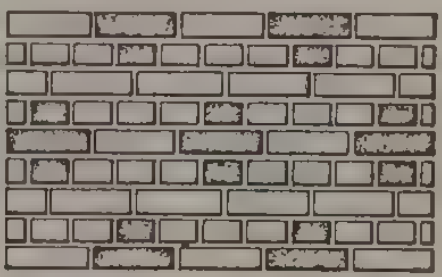
FLEMISH BOND
7.15 BRICK PER SQ FT.
(ALTERNATE FULL HEADERS EVERY 6TH COURSE)



BASKET PATTERN
6.75 BRICK PER SQ. FT.



FLEMISH CROSS BOND
7.15 BRICK PER SQ FT.
(ALTERNATE FULL HEADERS EVERY 6TH COURSE)

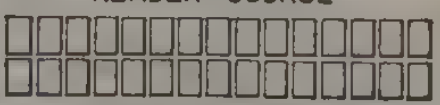


ENGLISH CROSS BOND
7.88 BRICK PER SQ. FT.
(CONTINUOUS FULL HEADERS EVERY 6TH COURSE)

STRETCHER COURSE

SOLDIER COURSE

HEADER COURSE



ROWLOCK COURSE

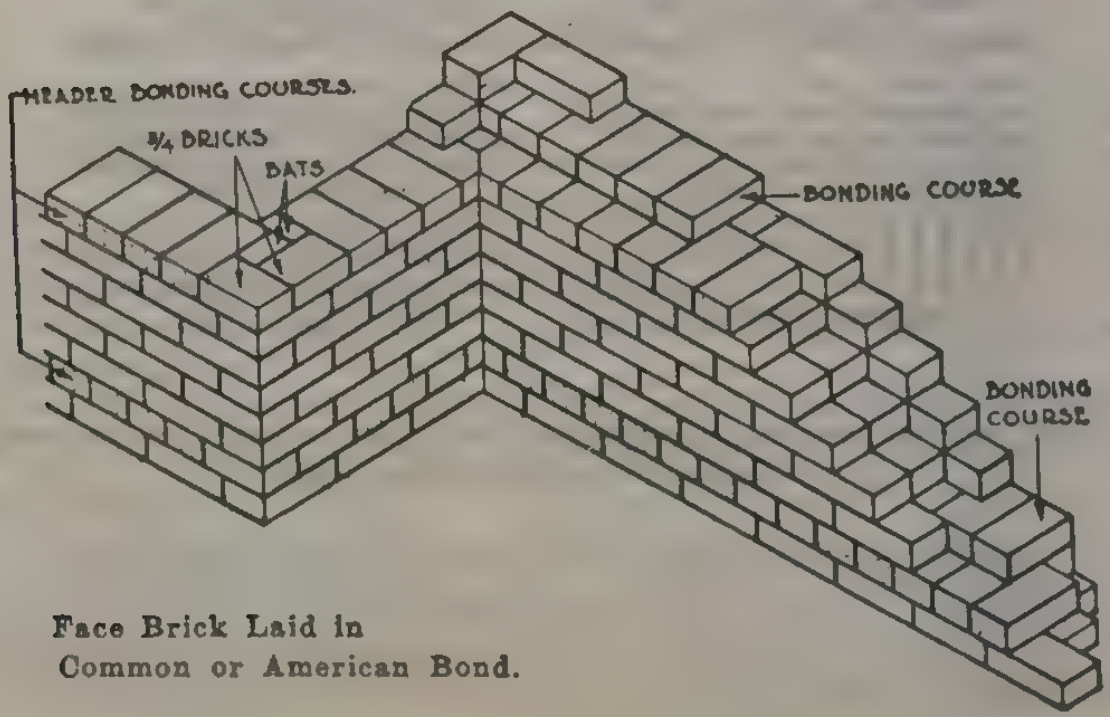
Elevations of Various Brick Bonds

English or English Cross* (full headers every other course)	50 % or $\frac{1}{2}$
English or English Cross* (full headers every 6th course)	$16\frac{2}{3}$% or $\frac{1}{6}$
Dutch or Dutch Cross* (full headers every other course)	50 % or $\frac{1}{2}$
Dutch or Dutch Cross* (full headers every 6th course)	$16\frac{2}{3}$% or $\frac{1}{6}$
Flemish (full headers every course)	$33\frac{1}{3}$% or $\frac{1}{3}$
Flemish (full headers every 6th course)	5.6% or $\frac{1}{18}$
Double Header (two headers and a stretcher every 6th course)	$8\frac{1}{3}$% or $\frac{1}{12}$
Double Header (two headers and a stretcher every 5th course)	10 % or $\frac{1}{10}$
Double Flemish (full headers every other course)	10 % or $\frac{1}{10}$

*Add 10 to 15 percent extra brick for waste in cutting unless a masonry saw is used.

Percentages To Be Added for Various Brick Bonds

Double Flemish (full headers every 3rd course)	$6\frac{2}{3}$% or $\frac{1}{15}$
3 Stretcher Flemish (full headers every other course)	$7\frac{1}{7}$% or $\frac{1}{14}$
3 Stretcher Flemish (full headers every 3rd course)	4.8% or $\frac{1}{21}$
4 Stretcher Flemish (full headers every other course)	5.6% or $\frac{1}{18}$
4 Stretcher Flemish (full headers every third course)	3.7% or $\frac{1}{27}$



Face Brick Laid in Common or American Bond.

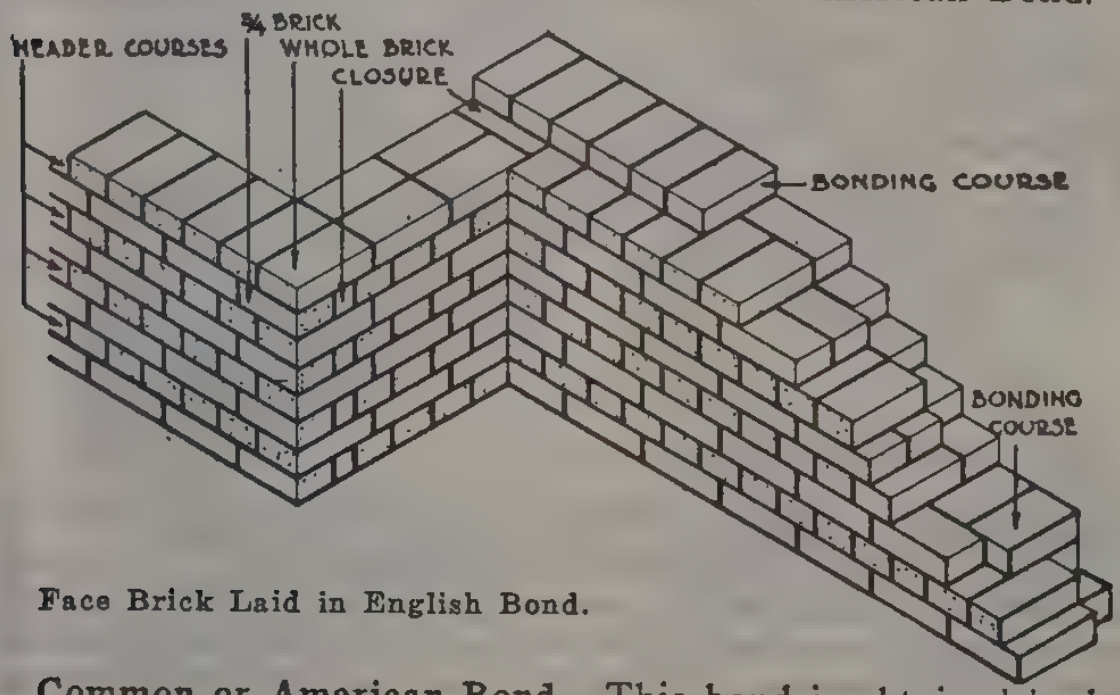
For garden walls, porch walls, and other places where an 8″ wall is used, with face brick on both sides of the wall, no additional brick are required for any type of wall.

For walks and floors with the brick laid on edge, in any pattern except diagonal, calculate as you would for face brick in common bond without headers. For herringbone or other diagonal work, additional brick will be required because of the waste in chipping or cutting the brick for the borders. The additional number of brick will vary with the width of the walk or floor, as the wider the surface, the smaller the average waste per sq. ft. Walks and floors having the brick laid flat require one-third less brick than where they are laid on edge.

Brick Bonds

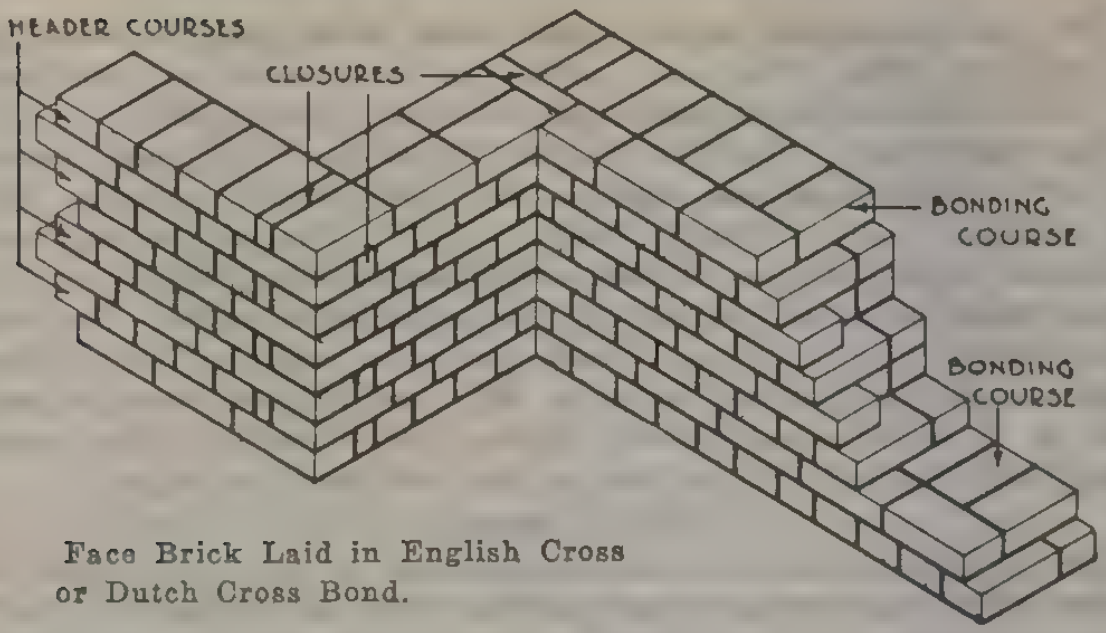
Bond in brickwork is the overlapping of one brick upon the other, either along the length of the wall or through its thickness, in order to bind them together into a secure structural mass. Units are shifted back and forth so that the vertical joints in two successive layers or "courses" do not come into line; in other words, the brick are laid so as to break the joint, the whole forming a natural bond or a structural unit giving strength to the wall.

Running or Stretcher Bond.—The wall surface is made up of stretcher courses having a header at the corners which appears as a stretcher on the return side. This bond is very strong longitudinally, but lacks transverse strength, consequently it is modified into what is called Common or American Bond.



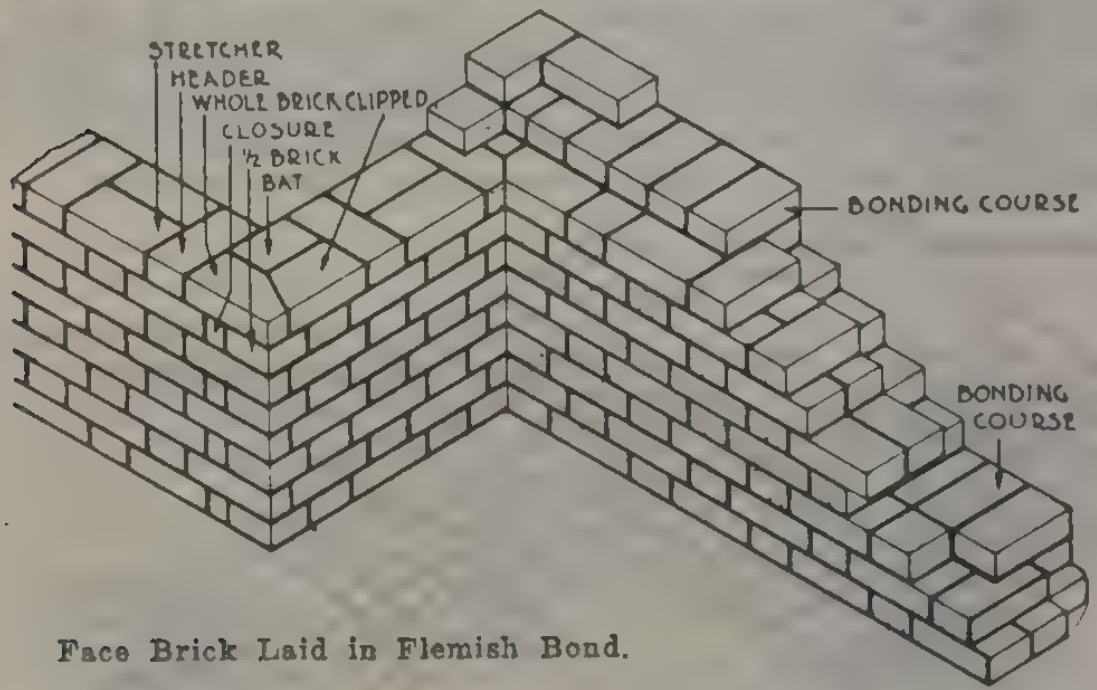
Face Brick Laid in English Bond.

Common or American Bond.—This bond is obtained by laying a course of headers every fifth, sixth or seventh course. To



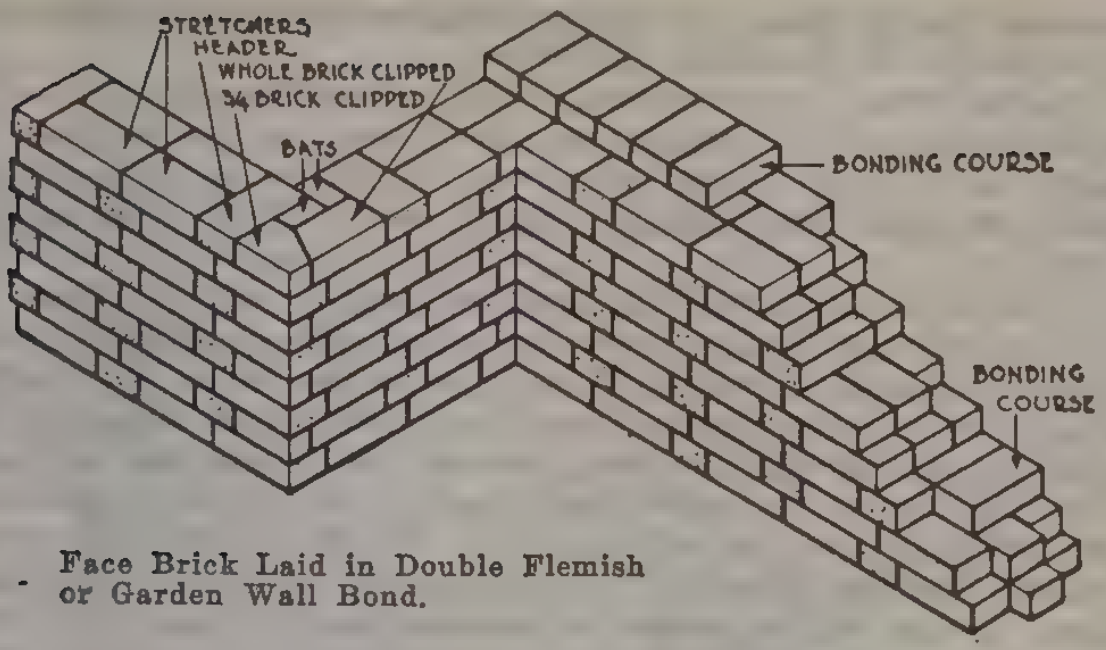
Face Brick Laid in English Cross or Dutch Cross Bond.

maintain the effect of the running bond, a special double header bond is sometimes used. This method of using headers as in Common or American Bond, in order to secure transverse strength of wall, can be treated in a way to produce more pleasing effects, as may be seen in Flemish or English Bonds.



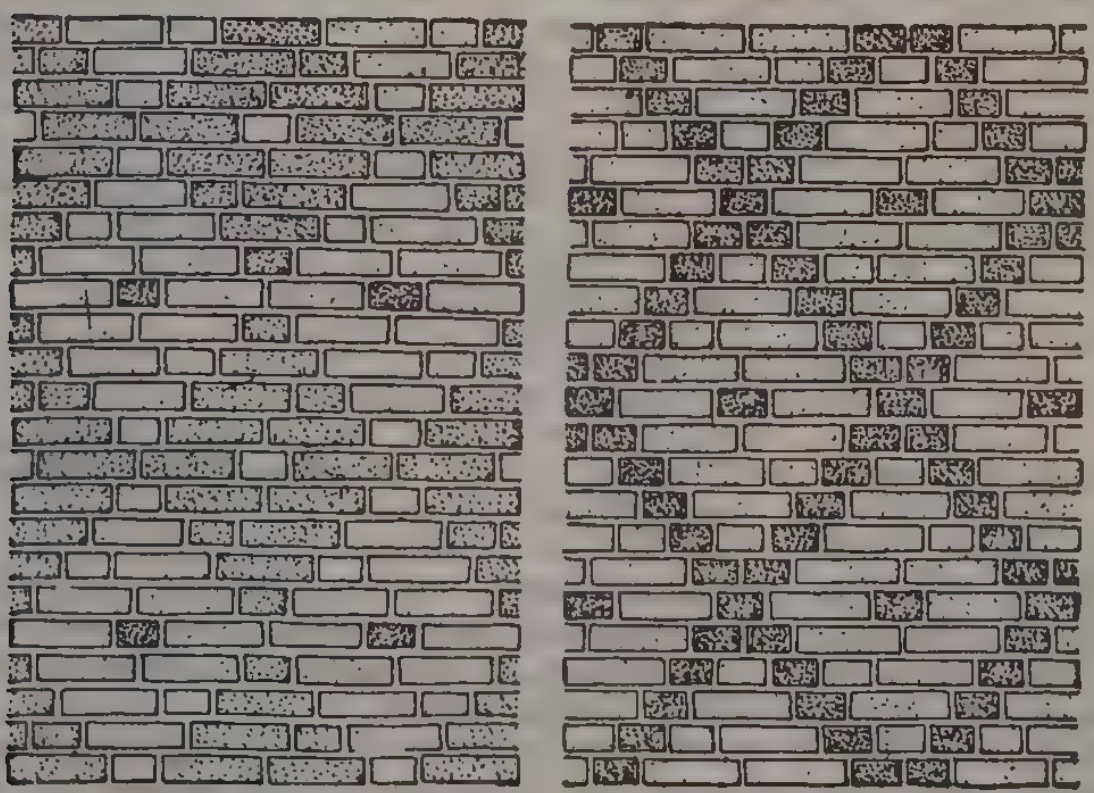
Face Brick Laid in Flemish Bond.

English Bond.—English Bond is made up of alternating courses of stretchers and headers. Ordinarily half brick are used for the header courses, except every sixth course a full header course is used to tie the face and common brick walls together. The allowance for headers is given on the previous page.



Face Brick Laid in Double Flemish or Garden Wall Bond.

Dutch Bond or English Cross Bond.—Dutch or English Cross Bond is similar to English Bond, except starting courses differ. Each course starts off with ¼, ½ or ¾ of a brick, alternating as shown in the illustration, and each successive course consists of stretchers and headers. On account of the large amount of cutting necessary to obtain the ¼ and ¾ pieces of brick, it is



Face Brick Laid in Diamond Bond Patterns.

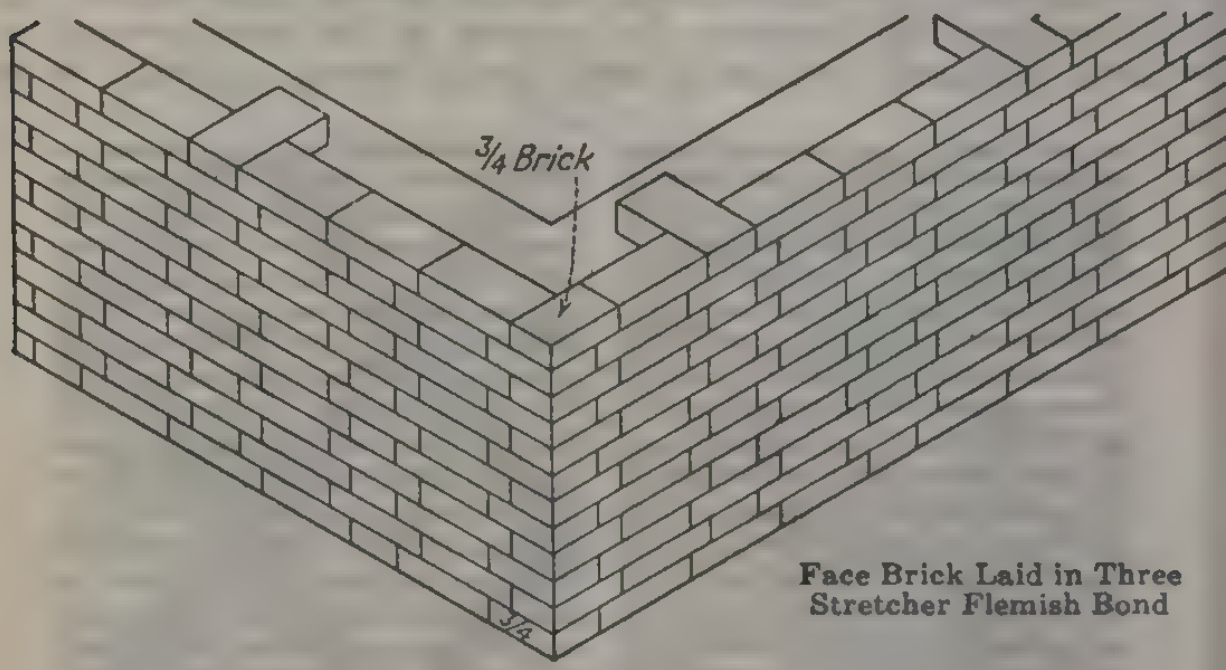
necessary to add 10 to 15 percent additional brick to allow for waste, caused by breakage in cutting.

However, waste in cutting may be greatly reduced if a masonry saw is used for this purpose, as a brick may be cut in 10 to 15 seconds and the resulting waste and spoilage of face bricks greatly reduced. See "Masonry Saws" under "Tools and Equipment."

If brick are laid with full header courses every second or sixth course, add the percentages given on the previous pages.

Flemish Bond.—Flemish Bond secures its effect by laying each course in alternate stretchers and headers, the header resting upon the middle of the stretcher in successive courses. When full brick are used for headers, it requires one-half more brick than where half brick or "blind" headers are used.

Double Flemish Bond.—The arrangement of bricks along the course so that each header is preceded and followed by two stretchers for the entire course. On consecutive courses, the position of the header is directly over the joint between the two stretchers. Each stretcher has a lap of three-fourths of its length over the stretcher beneath.

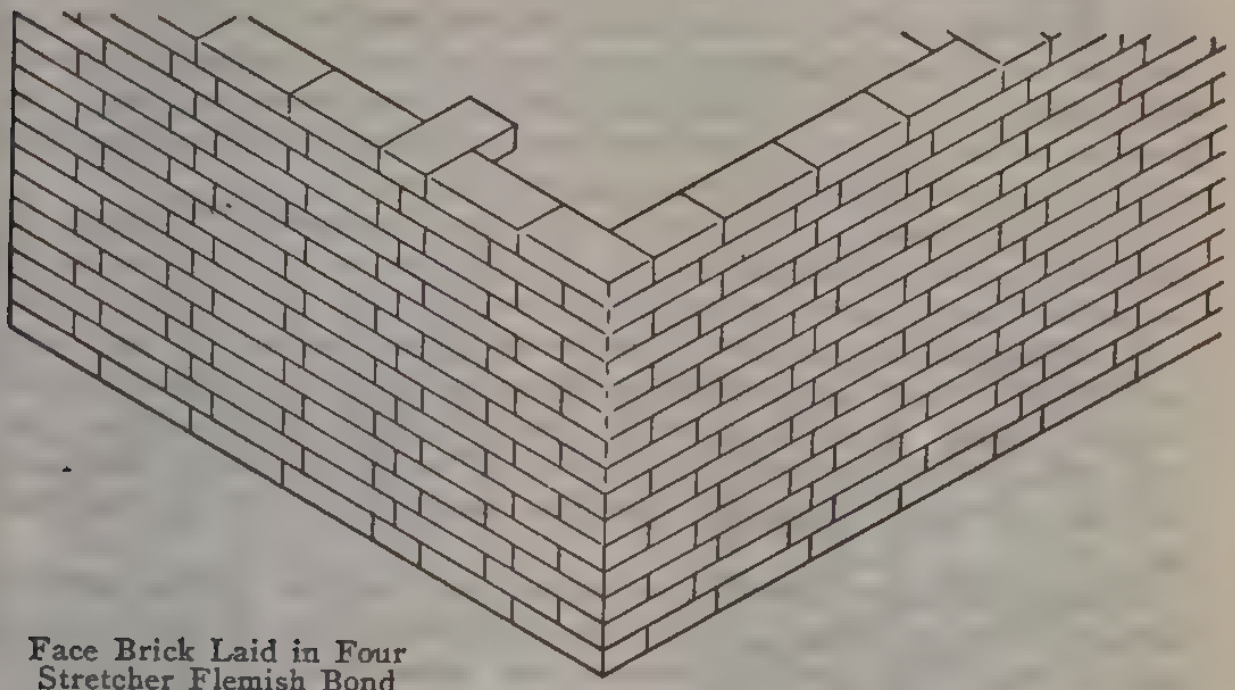


Face Brick Laid in Three Stretcher Flemish Bond

Three Stretcher Flemish Bond.—An arrangement of bricks along the course so that a header is placed between each sequence of three stretchers. The header of one course is centered over the middle stretcher of the course below.

Four Stretcher Flemish Bond.—In this bond, a header occurs between each sequence of four stretchers. The header of one course is centered between the headers of the course below.

The allowances for header courses are given on the previous pages.



Face Brick Laid in Four Stretcher Flemish Bond

Garden Wall Bond.—Garden Wall Bond is merely a modification of Flemish Bond, secured by laying courses with two to four stretchers alternating with a header, and requires the same number of brick per square foot as Flemish Bond.

Diamond Bond Patterns.—Diamond Bond Patterns are secured by a modification of the Garden Wall Bond. It is, however, only in case of large wall surfaces that patterns of an elaborate character could be recommended, as any departure from simple bonds adds to the cost of bricklaying.

Modular Size Brick

Economy is the prime objective of Modular Design. Its application has brought about economy of design, in layout and in construction.

While Modular Design involves the coordination of building materials, this basic principle is employed only as a means to the main objective—economy—and is not carried beyond the point where its use would defeat the main purpose.

It is not to be considered as a complex and revolutionary plan of coordinating building materials, but rather as a simplified and efficient system of design, layout and construction resulting in definite economies.

After an exhaustive study, a four inch module or increment was agreed upon as a unit that would afford the maximum

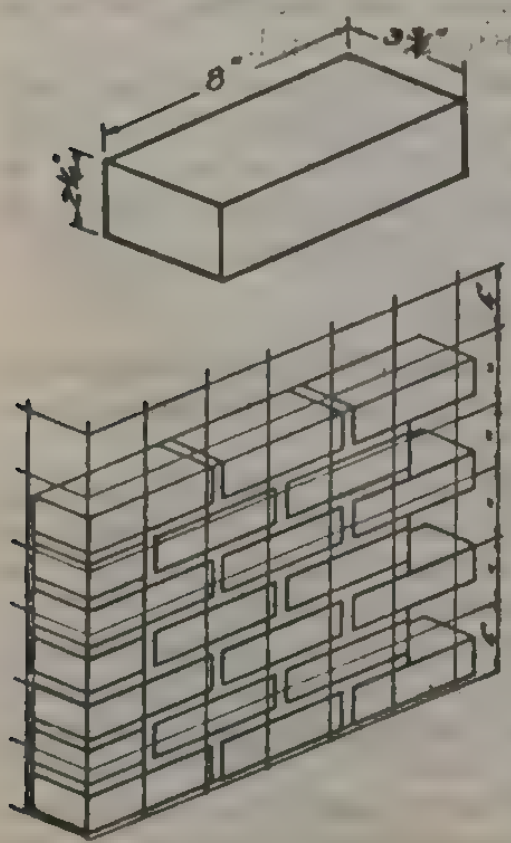
practical standardization and simplification, and at the same time afford a sufficient flexibility in design.

On the basis of the four inch module or increment, certain sizes of brick and tile have been recommended. In this connection, it must be remembered that the four inch module, governing both the vertical and horizontal dimensions, is used to govern the layout of finished wall areas and to determine heights and widths of doors, windows, other openings.

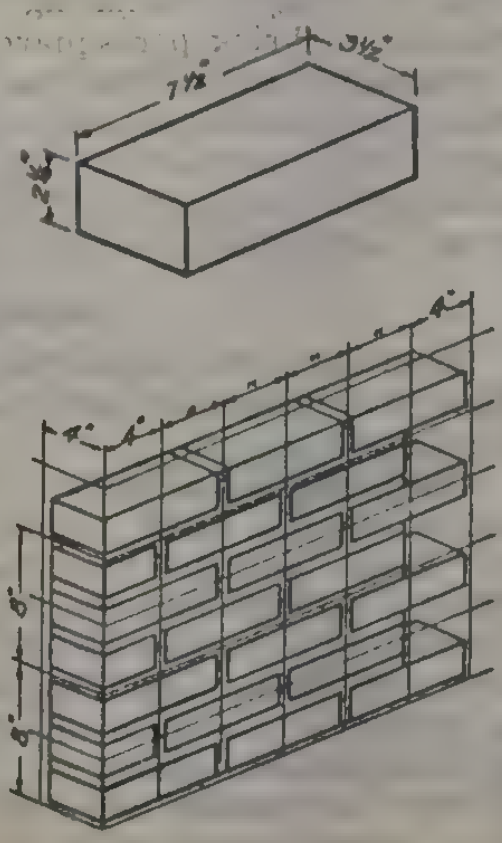
Since the module is a unit of wall measurement, it cannot be applied to the individual brick or tile, but must be considered as governing the size of the brick or tile, plus the mortar joint.

In employing the modular system of measurement for masonry walls, the dimension is considered from center to center of the mortar joints. Therefore, to fit properly into the modular system, the actual sizes of the individual units of either brick or tile are determined by the modular dimension less the mortar joint.

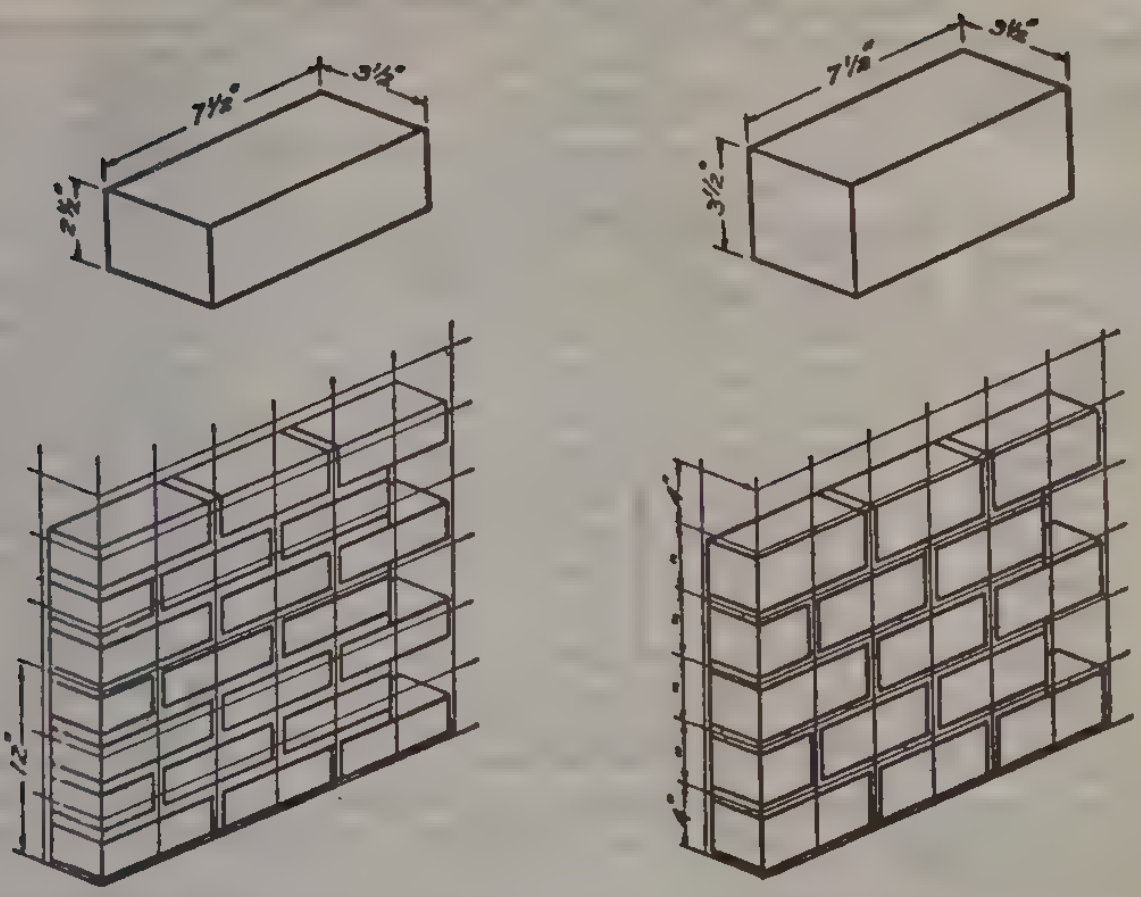
The explanatory details, drawn with ½" mortar joints, present this matter very clearly. The first illustration indicates a wall section built of standard size brick measuring 2¼"x3¾"x8". It will be noted that a unit of this size does not comply with the modular measurements as indicated by the four inch modular



Conventional Standard Brick



2-2/3" Modular Brick



8" Modular Brick

4" Modular Brick

dimension lines, known as grid lines. Therefore, if standard size brick are used in the construction of a project designed according to the modular system, wasteful cutting and fitting of the brick would be necessary.

Note the difference in the second wall section. In this case a modular brick is employed, having an actual size of $2\frac{1}{6}$"x$3\frac{1}{2}$"x$7\frac{1}{2}$". Using a $\frac{1}{2}$" mortar joint, three courses of brick lay up perfectly to every two horizontal grid lines, and one length of brick likewise fits two vertical grid lines. The same holds true of the other sizes of brick shown.

Exact heights of modular brick will vary, the difference being taken up in the bed joints. It is therefore important to know the exact size of brick. The following table lists standard joint widths.

Modular Face Brick

Three standard modular joint thicknesses are $\frac{1}{4}$", $\frac{3}{8}$", and $\frac{1}{2}$". The number of modular masonry units per square foot, of course, will remain constant for each nominal size, the difference being taken up in the joint.

Modular Brick Walls Without Headers

Nominal Brick Size in Inches h t l	Brick Per Sq Ft of Wall	Cubic Feet of Mortar Per 100 Sq Ft of Wall — Joint Thickness			Cubic Feet of Mortar Per 1000 Brick — Joint Thickness		
		¼ in.	⅜ in.	½ in.	¼ in.	⅜ in.	½ in.
2⅔x4x 8	6.750	3.81	5.47	6.95	5.65	8.10	10.30
3⅕x4x 8	5.625	3.34	4.79	6.10	5.94	8.52	10.84
4 x4x 8	4.500	——	4.12	5.24	——	9.15	11.65
5⅓x4x 8	3.375	——	3.44	4.34	——	10.19	12.87
2 x4x12	6.000	——	6.43	8.20	——	10.72	13.67
2⅔x4x12	4.500	3.52	5.06	6.46	7.82	11.24	14.35
3 x4x12	4.000	——	4.60	5.87	——	11.51	14.68
3⅕x4x12	3.750	3.04	4.37	5.58	8.11	11.66	14.89
4 x4x12	3.000	2.56	3.69	4.71	8.54	12.29	15.70
5⅓x4x12	2.250	——	3.00	3.84	——	13.34	17.05
2⅔x6x12	4.500	——	7.85	10.15	——	17.45	22.55
3⅕x6x12	3.750	——	6.79	8.77	——	18.10	23.39
4 x6x12	3.000	——	5.72	7.40	——	19.07	24.67

The above quantities include mortar for bed and vertical joints only. The following table gives allowances for backing mortar or collar joints.

Cubic Feet of Mortar Per 100 Sq Ft of Wall		
¼-in. Joint	⅜-in. Joint	½-in. Joint
2.08	3.13	4.17

Note: Cubic feet per 1000 units $= \frac{10 \times \text{cubic feet per 100 sq ft of wall}}{\text{number of units per square foot of wall}}$

Most face brick today is backed up by tile or block rather than building brick. Brick tables given above can be converted for tile and block units by referring to the table below.

Brick and Tile Equivalents

Nominal Tile Size t h l	Equivalent Brick Units	
	2⅔ by 4 by 8	4 by 4 by 8
4x 4 x12	2.25	1.50
4x 5⅓x12	3.00	2.00
4x 8 x12	4.50	3.00
4x12 x12	6.75	4.50
8x 4 x12	4.50	3.00
8x 5⅓x12	6.00	4.00
8x 8 x12	9.00	6.00
8x12 x12	13.50	9.00
12x12 x12	20.25	13.50

Labor Laying Building Brick

There are so many factors entering into the labor cost of laying building brick that an explanation is necessary to use the following data intelligently.

There are no set quantities of brick that a mason will lay per hr. or per day, and with 10 men laying brick on the same wall and on exactly the same class of work, no two of them will lay the same number of brick. For this reason averages must be taken. There are good mechanics and poor mechanics—there are conscientious mechanics who desire to do a full day's work and there are unscrupulous ones who do only enough to "get-by". There are others who never "get-by" and are on one job only long enough for the foreman to see they are incompetent and off they go.

Solid brick walls are used much less frequently now than previous to World War II, and where brick are used as a facing they are backed-up with cement blocks or hollow tile.

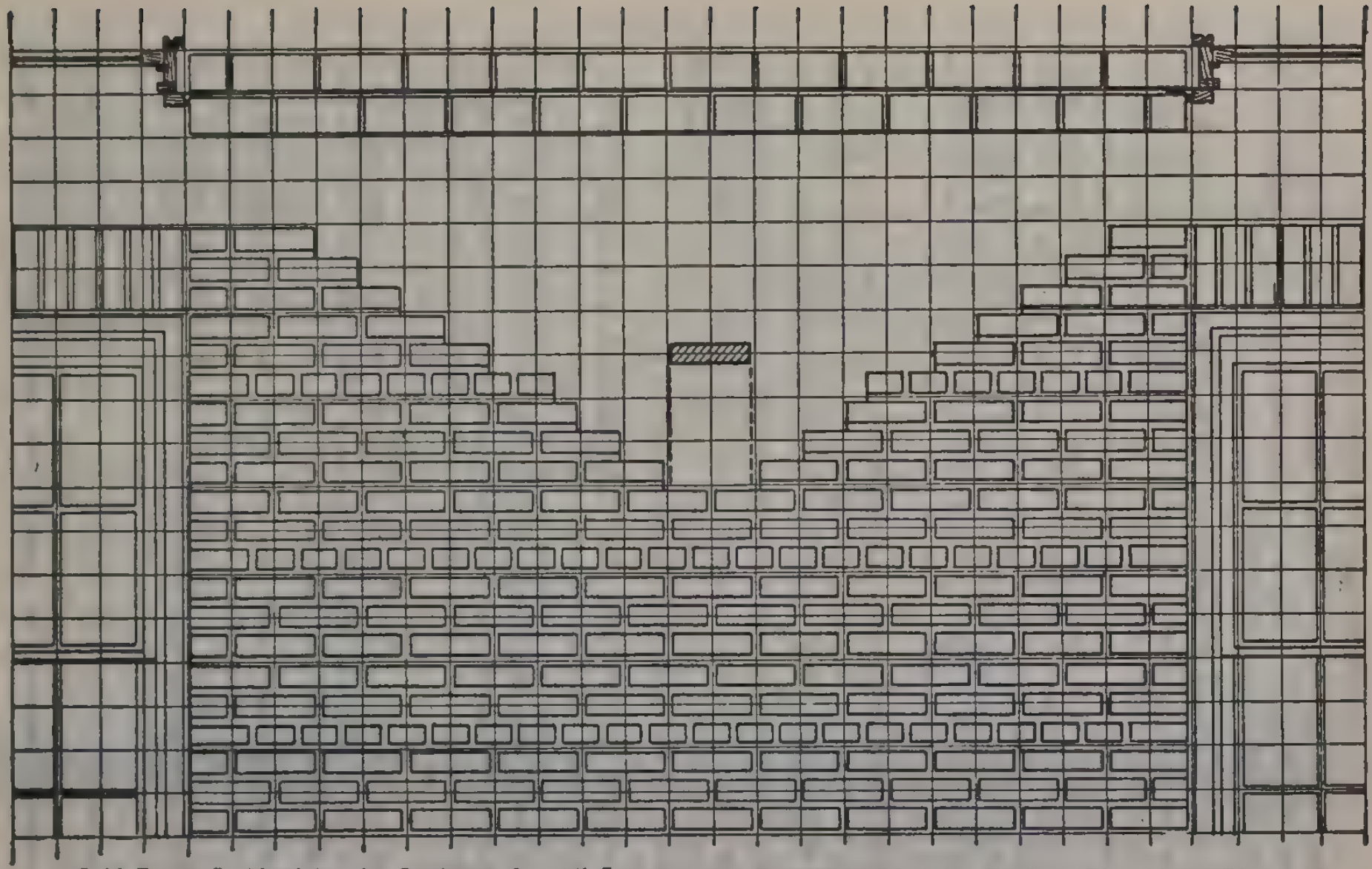
This is due to the lower labor costs in handling and setting the larger units of cement blocks and clay tile in comparison with the smaller units of brick, as one 8"x8"x16" cement block usually displaces 12 building brick in the wall.

The class of work also has a great deal to do with the variation in labor costs, as it costs much more to lay brick in an 8" wall with struck joints than in a 16" wall having cut joints on one side of the wall and struck joints on the other. Also, it costs more to lay brick in portland cement mortar than in lime mortar because the lime mortar spreads far more easily than cement mortar.

It costs more to lay brick in cold, wet weather when the brick are slippery and the mason's hands cold than in fair weather with all conditions favorable.

It requires more labor to lay brick in the winter when the brick and mortar must be heated and salamanders placed along the floor or scaffold, requiring addtional labor attending salamanders, removing ice, snow, etc., than in the summer when conditions are favorable.

It costs more to lay brick on a job having straight walls, plumb corners, and the brick laid in a good bed of mortar than on cheaply constructed speculative buildings having crooked



Grid Paper Is Used by the Designer for All Layouts and Details in Modular Design. The Above Plan and Elevation of Brick between Two Window Openings Show How the Brick Fit the Intervening Space Perfectly with No Wasteful Cutting or Fitting.

walls and practically no mortar between courses—a "sloppy" job that will require repairs as soon as the building is finished.

The quantities and costs given on the following pages are based on a good grade of workmanship applicable to the type of building on which it is to be used. The same class of workmanship has not been figured on the bungalow and apartment building that is required on a high grade school, university building, a U. S. Government Post Office or buildings of that type, but neither has the cheapest grade of workmanship been figured. Judgment and common sense are necessary when applying any figures, otherwise anyone could be a "successful" estimator and contractor.

The quantities given are based on the performances of experienced masons working regularly at their trade under present conditions. They will not hold good in small communities where the mason does the cement work and plastering as well as the bricklaying and stone setting of the community.

The costs are based on efficient management and supervision, the use of modern tools and appliances, machine mortar mixers, etc., on jobs large enough to warrant their use. On jobs of sufficient size to require a mason foreman, it will be necessary to add for this time on the basis of a certain price per 1,000 brick or at a certain price per week, based on the estimated duration of the job.

Labor Laying Face Brick

The labor cost of laying face brick will vary with the grade of workmanship, style of bond in which the brick are laid, width and kind of mortar joint, type of building, whether long, straight walls or walls cut up with pilasters, door and window openings, etc., and last but not least, the ability of the foreman in charge—a good foreman will probably have competent masons and vice versa.

Costs are given on two classes of work, Ordinary and First Grade.

Ordinary workmanship should be used for all buildings of average construction, such as brick dwellings, store and apartment buildings, ordinary school buildings, factory and warehouse buildings, speculative apartment buildings, apartment hotels, etc.

First Grade workmanship is intended to cover all of the better class of buildings, such as high-grade fireproof hotel and apartment buildings, fireproof office buildings, fine residences, bank buildings, courthouses, U. S. post offices and other federal government structures, state capitol buildings, school and uni-

Labor Costs Laying Building Brick

Class of Work	Mortar Joints Style	Kind of Mortar	Average Number Brick Laid per 8-hr. Day	Aver. Hrs. 1,000 Brick		
				Mason Hours	Labor Hours	Hoist Engr.*
8″ walls, 1-story bungalows, garages, two-flat buildings, residences, etc.	Cut	Lime	750–800	10.5	9.0	.....
	Struck	Lime	700–750	11.0	9.0	.....
12″ walls, ordinary construction, apartment buildings, houses, garages, factories, stores, store and apartment buildings, schools, etc.	Cut	Lime	950–1,050	8.0	8.0	.....
	Struck	Lime	925–975	8.5	8.0	.....
	Cut	Cement	825–900	9.3	8.0	.....
	Struck	Cement	750–850	10.0	8.0	.....
Hodding brick to second story, add	.....	.....	.....	.. ..	2.0	.....
16″ walls, heavy warehouse, factory and industrial work. Straight walls	Cut	Lime	1,100–1,225	7.0	8.0	.....
	Struck	Lime	1,000–1,125	7.5	8.0	.....
	Cut	Cement	950–1,050	8.0	8.0	.....
	Struck	Cement	900–1,000	8.4	8.0	.....
Backing-up face brick, cut stone, terra cotta on ordinary wall bearing buildings, figure same as given above for 8″ and 12″ walls	.....	.....	.....	.. ..	.. ..	.....

WINTER WORK. Heating brick, mortar, attending salamanders, removing snow and ice, add extra for this work.

*HOISTING. Add about ¼-hr. hoisting engineer time per 1,000 for reasonable size jobs using 35,000 or more brick per day; ½-hr. per 1,000 for jobs using 15,000 to 20,000 brick per day; and ⅓-hr. per 1,000 for jobs using 25,000 to 30,000 brick per day.

If automatic hoists are used, omit all time for hoisting engineer.

Labor Costs Laying Building Brick—Cont.

Class of Work	Mortar Joints Style	Kind of Mortar	Average Number Brick Laid per 8-hr. Day	Aver. Hrs. 1,000 Brick		
				Mason Hours	Labor Hours	Hoist Engr.*
Backing-up face brick, cut stone, terra cotta on steel or concrete skeleton frame buildings. First Grade workmanship. Walls 8″ to 12″ thick.	Cut	Lime	825–900	9.3	9.0	.....
	Struck	Lime	750–850	10.0	9.0	.....
	Cut	Cement	725–800	10.5	9.0	.....
	Struck	Cement	700–775	10.8	9.0	
Public buildings, First Grade workmanship. Schools, college and university bldgs. Courthouses, state capitols, public libraries, etc. 12″ to 20″ walls.	Cut	Lime	850–950	9.0	8.0	.....
	Struck	Lime	800–900	9.4	8.0	.....
	Cut	Cement	750–850	10.0	8.0	.....
	Struck	Cement	700–800	10.6	8.0	.....
Powerhouses and other structures, having high walls 12″ to 20″ thick, without intermediate floors.	Cut	Lime	1,100–1,200	7.0	9.0	.....
	Struck	Lime	1,000–1,100	7.6	9.0	.....
	Cut	Cement	925–1,050	8.0	9.0	.....
	Struck	Cement	875–950	8.8	9.0	.....
Shoved joints. Brick laid in full shoved joints with all vertical joints slushed full of mortar, add to all of the above	.....	.....	.....	1.5	.....	.....
Basement foundation walls, paving brick.	Cut	Cement	900–1,000	8.5	8.5	.....
	Struck	Cement	850–950	9.0	9.0	.....

WINTER WORK. Heating brick, mortar, attending salamanders, removing snow and ice, add extra for this work.

*HOISTING. Add about ¼-hr. hoisting engineer time per 1,000 for reasonable size jobs using 35,000 or more brick per day; ½-hr. per 1,000 for jobs using 15,000 to 20,000 brick per day; and ⅓-hr. per 1,000 for jobs using 25,000 to 30,000 brick per day.

If automatic hoists are used, omit all time for hoisting engineer.

Labor Costs Laying Building Brick—Cont.

Class of Work	Mortar Joints Style	Kind of Mortar	Average Number Brick Laid per 8-hr. Day	Aver. Hrs. 1,000 Brick		
				Mason Hours	Labor Hours	Hoist Engr.*
Building brick foundation walls 8″ to 12″ thick, ordinary workmanship.	Cut	Lime	1,000–1,100	7.6	8.0	.....
	Struck	Lime	900–975	8.5	8.0	.....
	Cut	Cement	900–975	8.5	8.0	.....
	Struck	Cement	825–900	9.3	8.0	.....
Chimneys and stacks, building brick, 1′–4″ to 2′–0″ sq. 15′–0″ above roof, 4″ to 8″ walls.	Struck	Lime	500–550	16.0	16.0	.....
Hodding brick, extra.	.....	.....	.....	....	3.0	.....
Large chimneys and stacks, 3′–0″ to 4′–0″ Sq. 15′ to 30′ high above roof, 8″ to 12″ walls.	Struck	Lime	550–600	14.0	16.0	.....
Large brick stacks 100′ to 150′ high, walls from 1′–8″ at base to 12″ top. Inside put-log scaffold. Outside scaffold extra.	Struck	Lime	650–750	11.5	14.0	.....
Bricking-in boilers, fire-boxes, etc.	Struck	.....	600–650	12.5	10.0	.....

WINTER WORK. Heating brick, mortar, attending salamanders, removing snow and ice, add extra for this work.

*HOISTING. Add about ¼-hr. hoisting engineer time per 1,000 for reasonable size jobs using 35,000 or more brick per day; ½-hr. per 1,000 for jobs using 15,000 to 20,000 brick per day; and ⅓-hr. per 1,000 for jobs using 25,000 to 30,000 brick per day.

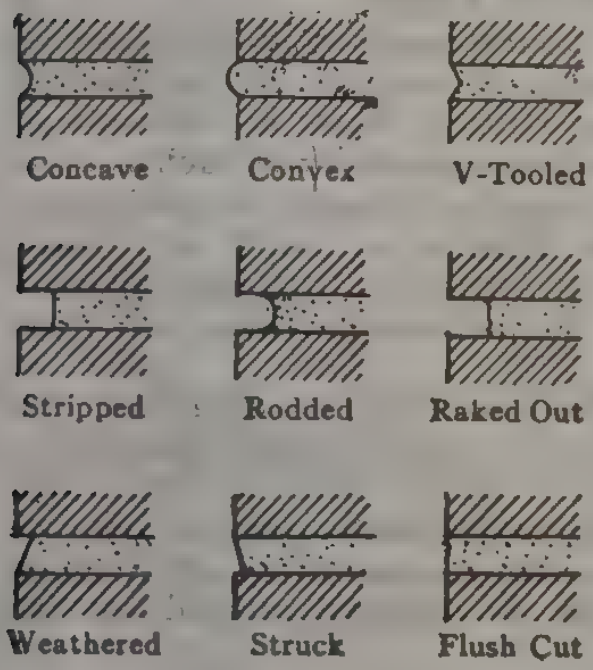
If automatic hoists are used, omit all time for hoisting engineer.

versity buildings, and all structures where the best grade of workmanship is required.

Common bond is the most economical method of laying face brick, and other styles, such as English, Flemish, Dutch and Garden Wall bond, require more labor on account of the various patterns and the additional cutting required. This is especially so on First Grade work where all vertical mortar joints must be plumb.

For instance, when laying Dutch, English and Flemish brick bonds, and the many variations of same, it is necessary to do a great deal of cutting, especially where half brick are used for headers, and it requires just as much time to cut the brick, spread mortar to lay one-half brick as for a full brick.

The labor cost of laying 1,000 face brick in Dutch, English or Flemish bond will be more if half-brick are used for headers than where full brick are used because it will take just as much time to cut, spread mortar bed, apply mortar to brick, lay same and cut the joints whether a full or half brick is used.



Styles of Mortar Joints.

The style of mortar joint has considerable bearing on the labor costs. The flush cut joint is the most economical because the bricklayer cuts off the excess mortar with his trowel and the joint is finished. For concave, V-tooled, weathered and struck joints, it is necessary to cut off the excess mortar with the trowel and then another operation is required, using a trowel for the weathered or struck joints or a jointing tool for concave and V-tooled. For raked-out joints, a bricklayer must rake out the mortar ¼" to ⅜" back from the face of the brick, and for a rodded joint, the bricklayer must rake out the excess mortar and then strike the joint with a jointer. These operations all require time and cost money with bricklayers' wages at their present level.

The stripped joint is the most expensive of any illustrated, as it is necessary to place narrow wood strips in the mortar

joints between each course of brick, and these strips must remain until the mortar has set, so it will not squeeze out toward the face of the brick.

It is slow work laying brick where the joints are stripped.

If face brick are laid with $\frac{7}{8}$" or 1" bed mortar joints, the work proceeds very slowly and requires a stiff mortar because the weight of the top brick courses squeeze the mortar out of the lower mortar joints, producing an uneven appearance. For this reason the work cannot be carried up many courses at a time. Where the joints are struck, it is necessary for the mortar to take its initial set before the joints can be struck to produce a workmanlike job. Brick work of this kind is very expensive.

The quantities and costs given on the following pages are intended to cover all kinds of face brick work, whether laid in veneer in frame buildings, in solid brick or brick and tile walls.

Labor Laying Face Brick in English, Flemish, Dutch, Garden Wall and Diamond Bonds

Face brick laid in any of the above bonds with the courses consisting of various arrangements of headers and stretchers requires considerable extra labor cutting brick on account of the large number of "bats" or headers required for each course. Ordinarily, a full header course extends through the wall every 5th or 6th course, and the other headers are only half brick. On First Grade workmanship it is necessary to plumb all vertical mortar joints in order that the various patterns will work out accurately.

For a description of the labor involved in obtaining the various styles of mortar joints, refer to the preceding paragraph.

Basing the labor laying brick in Common Bond as 100, it will require approximately the following additional time to lay face brick in Dutch, English and the different variations of Flemish bond, where half brick are used as headers instead of full brick.

Kind of Bond	Percentage
Common Bond using Full Headers	100
Dutch Bond using Full Headers every other Course	120
Dutch Bond using Full Headers every Sixth Course	129
English Bond using Full Headers every other Course	120
English Bond using Full Headers every Sixth Course	129
Flemish Bond using Full Headers every Course	120
Flemish Bond using Full Headers every Sixth Course	126

Kind of Bond	Percentage
Double Flemish Bond using Full Headers every Course	100
Double Flemish Bond using Full Headers every Sixth Course	116
3-Stretcher Flemish Bond using Full Headers every Other Course	107
3-Stretcher Flemish Bond using Full Headers every Sixth Course	112
4-Stretcher Flemish Bond using Full Headers every Other Course	106
4-Stretcher Flemish Bond using Full Headers every Sixth Course	109

Double Size Building Brick

Double size building brick ($3\frac{3}{4}$"x5"x8"), are used in different parts of the country. Their use effects a saving in both mortar and labor over standard size common brick ($3\frac{3}{4}$"x$2\frac{1}{4}$"x8").

Each brick contains 40 sq. in. on the face and when laid with a $\frac{1}{2}$" bed or horizontal joint and a $\frac{1}{4}$" vertical or end joint, covers 45.375 or $45\frac{3}{8}$ sq. in. and requires 3.2 brick per sq. ft. of 4" wall; 6.4 brick per sq. ft. of 8" wall and 9.6 brick per sq. ft. of 12" or 13" wall, not including any allowance for waste.

Mortar Required for Double Size Building Brick

Based on $\frac{1}{2}$" bed or horizontal joints and $\frac{1}{4}$" end or vertical joints.

Mortar Required per 1,000 Double Brick			Mortar Required per 100 Sq. Ft. of Wall		
4" Walls*	8" Walls	12" Walls	4" Walls*	8" Walls	12" Walls
$12\frac{3}{4}$ Cu. Ft.	$19\frac{1}{4}$ Cu. Ft.	$21\frac{1}{4}$ Cu. Ft.	4 Cu. Ft.	$12\frac{1}{4}$ Cu. Ft.	$20\frac{1}{2}$ Cu. Ft.

*Free Standing Walls.

No allowance for waste included in the above quantities.

Labor Laying Double Size Building Brick.—A mason will lay about 60 percent as many double brick ($3\frac{3}{4}$"x5"x8") brick as standard size building brick ($3\frac{3}{4}$"x$2\frac{1}{4}$"x8"), i. e., if a mason lays 800 building brick on a certain class of work, he would lay 480 double size building brick on the same class of work. In other words, if it required 10 hrs. mason time per 1,000 building brick, it would require $1\frac{2}{3}$ as many hours per 1,000 double brick, i.e., $10 \times 1.667 = 16.67$ or $16\frac{2}{3}$ hrs. mason time per 1,000 double brick.

Twin Brick

Twin brick is a double size brick that contains the face brick and a 4" backing brick in one unit, size 8"x8"x$2\frac{1}{4}$".

Labor Laying 1,000 Standard Size (8″x2¼″x3¾″) or Modular Size (7⅝″x2¼″x3⅝″) Face Brick in Common Bond

2:1:9 Lime-Cement Mortar				Ordinary Workmanship	Cement Mortar			
Mason Hours	Labor Hours	Hoist Engr.*	Number Laid per 8-Hr. Day	Style of Mortar Joint	Number Laid per 8-Hr. Day	Mason Hours	Labor Hours	Hoist. Engr.*
16.0	12	0.5	475–525	Flush Cut	425–475	17.8	13	0.5
17.8	12	0.5	425–475	V-Tooled or Concave	400–450	19.0	13	0.5
18.0	12	0.5	420–450	Struck or Weathered	390–435	19.5	13	0.5
17.8	12	0.5	425–475	Raked Out	400–450	19.0	13	0.5
19.0	12	0.5	400–450	Rodded	375–425	20.0	13	0.5
26.7	15	0.5	275–325	Stripped	275–300	27.8	16	0.5
				First Grade Workmanship				
19.0	13	0.5	400–450	Flush Cut	375–425	20.0	14	0.5
20.0	13	0.5	375–425	V-Tooled or Concave	360–400	21.0	14	0.5
21.0	13	0.5	360–400	Struck or Weathered	350–390	21.5	14	0.5
20.0	13	0.5	375–425	Raked Out	360–400	21.0	14	0.5
23.0	13	0.5	325–360	Rodded	300–340	25.0	14	0.5
32.0	16	0.5	225–275	Stripped	200–240	36.5	18	0.5
32.0	16	0.5	225–275	⅞″ to 1″ Flush Cut	200–240	36.5	18	0.5
36.0	16	0.5	200–250	⅞″ to 1″ Struck	190–230	38.0	18	0.5

*Add hoisting engineer's time only if required.

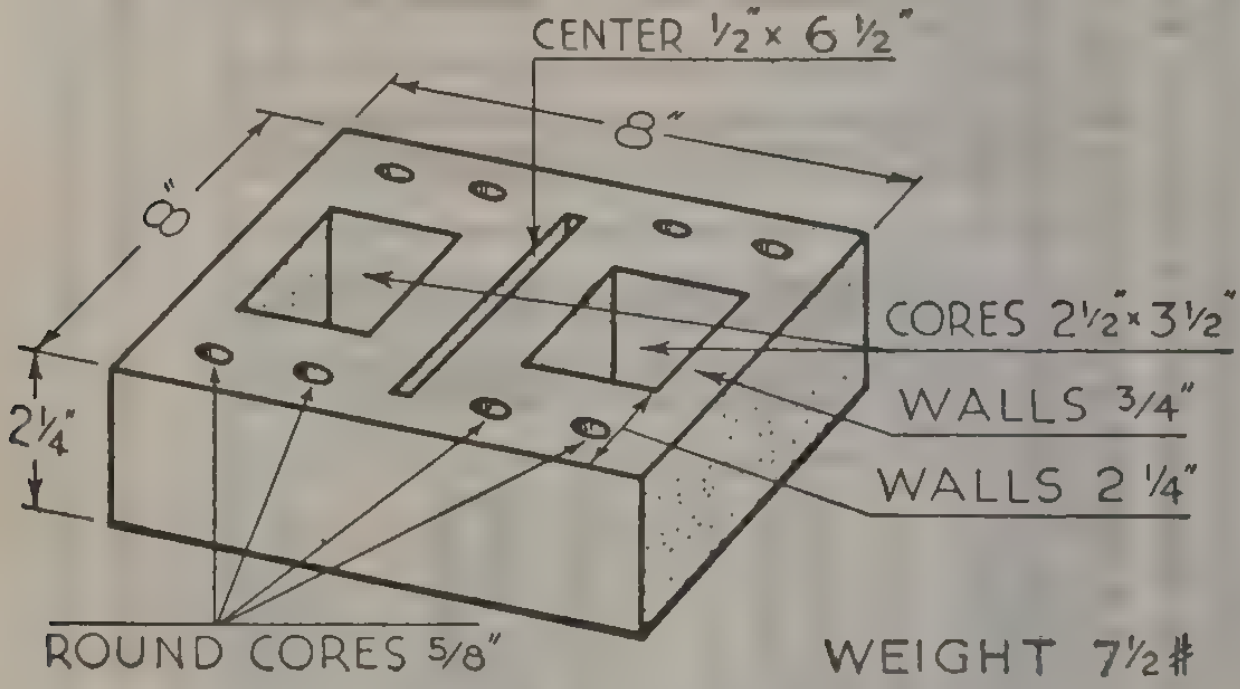
Labor Laying 1,000 Standard Size (8″x2¼″x3¾″) or Modular Size (7⅝″x2¼″x3⅝″) Face Brick in English, Flemish, Dutch and Garden Wall Bond, Laid with Full Headers Every 6th Course****

2:1:9 Lime-Cement Mortar				Ordinary Workmanship	Cement Mortar			
Mason Hours	Labor Hours	Hoist Engr.*	Number Laid per 8-Hr. Day	Style of Mortar Joint	Number Laid per 8-Hr. Day	Mason Hours	Labor Hours	Hoist. Engr.*
20.0	12	0.5	380–420	Flush Cut	360–400	21.0	13	0.5
21.3	12	0.5	350–400	V-Tooled or Concave	330–380	22.5	13	0.5
22.5	12	0.5	335–375	Struck or Weathered	320–360	23.5	13	0.5
21.3	12	0.5	350–400	Raked Out	330–380	22.5	13	0.5
22.5	12	0.5	335–375	Rodded	320–360	23.5	13	0.5
29.0	15	0.5	250–300	Stripped	240–285	31.0	15	0.5
				First Grade Workmanship				
22.5	13	0.5	335–375	Flush Cut	320–355	23.7	14	0.5
24.0	13	0.5	315–350	V-Tooled or Concave	300–335	25.0	14	0.5
25.0	13	0.5	300–340	Struck or Weathered	285–325	26.5	14	0.5
24.0	13	0.5	315–350	Raked Out	300–335	25.0	14	0.5
26.7	13	0.5	275–325	Rodded	260–310	29.0	14	0.5
35.5	16	0.5	200–250	Stripped	190–240	37.0	18	0.5
35.5	16	0.5	200–250	⅞″ to 1″ Flush Cut	190–240	37.0	18	0.5
40.0	16	0.5	175–225	⅞″ to 1″ Struck	165–215	42.0	18	0.5

*Add hoisting engineer's time only if required.

**If laid with full headers every course or every 2nd course, increase quantities laid approximately 8 percent.

It is made with a hollow core so that the twin brick weighs only 7½ lbs. and can be picked up and laid in a one-hand operation. It is designed so the wall has no continuous mortar joint from outer to inner wall faces, thereby tending to avoid moisture penetration.



Twin Brick. Size 8"x8"x2¼"

It is intended primarily for residential work having 8" walls that are to be furred and plastered. Extra face brick must be used at openings and corners to insure proper bond.

It requires about 25 cu. ft. of mortar per 1,000 units.

On four jobs on which these brick were used, requiring 50,000 units, a mason laid 60 twin brick an hour or 480 per 8 hr. day, at the following labor cost per 1,000 units:

	Hours	Rate	Total	Rate	Total
Mason	17	$.....	$.....	$7.10	$120.70
Labor	11.5	.....	.....	5.00	57.50
Cost per 1,000 units	28.5		$.....		$178.20

Skintled Brickwork

Skintled brickwork is enjoying a revival, particularly in store-front work and interiors of the "Olde English Pub" variety.

Skintled brickwork consists of laying common brick irregularly, with random projecting brick at intervals and using clinkers or irregular and other off-colored brick to produce a variegated wall.

These brick are laid in a number of different ways to produce the desired effect. In some of them the mortar projects beyond the face of the brick just as it has been squeezed out of the joint; in others the joints are cut flush or raked out to produce shadows, etc.

The labor cost will vary with the design and care used in laying up the brick.

When laying building brick without regard to color of wall and with uncut mortar joints or joints cut flush with the face of the wall, a mason should lay 350 to 400 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	21	$.....	$.....	$7.10	$149.10
Labor	15	.....	.....	5.00	75.00
Cost per 1,000 brick	36		$.....		$224.10

If brick joints are raked out, add 2.5 hrs. mason time per 1,000 brick.

On skintled brickwork using clinkers and other dark or irregularly shaped brick to produce a textured wall, more care is required in laying the brick, working out the designs and in raking out the joints to produce shadows, etc., and a mason should lay 250 to 300 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	29	$.....	$.....	$7.10	$205.90
Labor	20	.....	.....	5.00	100.00
Cost per 1,000 brick	49		$.....		$305.90

English Size Face Brick

English size face brick, $8\frac{7}{8}$"x$2\frac{7}{8}$"x4" in size, are seldom used in this country any more and while the size is not standard, they are still furnished by a few manufacturers.

Inasmuch as they are practically half again as large on the face as the standard brick, a mason is unable to lay as many as where the standard size brick are used. They also require more labor time handling, hoisting and wheeling to the masons.

Number of English Size, $8\frac{7}{8}$"x$2\frac{7}{8}$"x4", Face Brick Required Per Sq. Ft. of Wall

All Vertical Mortar Joints Figured ¼" Wide

	Width of Horizontal or "Bed" Mortar Joints in Inches					
Dry	⅛"	¼"	⅜"	½"	⅝"	¾"
5.65	5.34	5.06	4.88	4.67	4.52	4.37

Add for waste, headers and the different brick bonds as given on the previous pages under Standard Size Face Brick.

Labor Laying 1,000 English Size, $8\frac{7}{8}$"x$2\frac{7}{8}$"x4" Face Brick

2:1:9 Lime-Cement Mortar				Common Bond	Cement Mortar			
Mason Hours	Labor Hours	Hoist Engr.*	Number Laid per 8-Hr. Day	Style of Mortar Joint	Number Laid per 8-Hr. Day	Mason Hours	Labor Hours	Hoist. Engr.*
22.5	17	0.6	335–375	Flush Cut	320–360	23.5	18	0.6
23.5	17	0.6	325–360	V-Tooled or Concave	310–340	24.6	18	0.6
26.3	17	0.6	285–325	Struck or Weathered	275–315	27.0	18	0.6
23.5	17	0.6	325–360	Raked Out	310–340	24.6	18	0.6
28.5	17	0.6	260–300	Rodded	250–290	29.5	18	0.6
				English, Flemish or Dutch Bond				
24.7	17	0.6	300–350	Flush Cut	285–325	26.3	18	0.6
26.3	17	0.6	285–325	V-Tooled or Concave	275–310	27.0	18	0.6
28.5	17	0.6	260–300	Struck or Weathered	250–290	29.5	18	0.6
26.3	17	0.6	285–325	Raked Out	275–310	27.0	18	0.6
31.0	17	0.6	240–275	Rodded	230–265	32.2	18	0.6

*Add hoisting engineer's time only if required.

Labor Laying 1,000 Standard Size 8"x2¼"x3¾" Vitrified Face Brick

2:1:9 Lime-Cement Mortar				Common Bond	Cement Mortar			
Mason Hours	Labor Hours	Hoist Engr.*	Number Laid per 8-Hr. Day	Style of Mortar Joint	Number Laid per 8-Hr. Day	Mason Hours	Labor Hours	Hoist. Engr.*
31.0	17	0.6	235–275	Buttered and Struck	225–265	32.7	18	0.6
22.5	16	0.6	335–375	Flush Cut	320–360	23.5.	17	0.6
23.5	16	0.6	320–360	V-Tooled or Concave	300–340	25.0	17	0.6
26.3	16	0.6	285–325	Struck or Weathered	270–310	27.5	17	0.6
23.5	16	0.6	320–360	Raked Out	300–340	25.0	17	0.6
28.5	16	0.6	260–300	Rodded	250–285	30.0	17	0.6
				English, Flemish or Dutch Bond**				
34.8	17	0.6	210–250	Buttered and Struck	200–240	36.4	17	0.6
25.0	16	0.6	300–340	Flush Cut	285–325	26.3	17	0.6
26.3	16	0.6	285–325	V-Tooled or Concave	275–310	27.3	17	0.6
28.5	16	0.6	260–300	Struck or Weathered	250–290	29.7	17	0.6
26.3	16	0.6	285–325	Raked Out	275–310	27.3	17	0.6
31.0	17	0.6	235–275	Rodded	225–265	32.7	17	0.6

*Add hoisting engineer's time only if required.

**Full headers every sixth course. If full headers every other course, increase quantities laid approximately 8 percent.

Roman Face Brick

Roman size face brick, 12"x1½"x4" were extensively used some years ago for facing many types of buildings. Generally, they were laid with thin "buttered" joints and most of the original brick were made by the dry-pressed method and were relatively expensive.

Within the past few years, the modular Roman brick was introduced having a nominal size of 12"x2"x4", including mortar joint, while the actual brick size is $11\frac{5}{8}$"x$1\frac{5}{8}$"x$3\frac{5}{8}$", requiring a $\frac{3}{8}$" mortar joint to lay 2" high and 12" long. These brick are furnished with either standard brick textured faces or a split (rock-like) texture. The split face is generally preferred as it greatly accentuates the horizontal bonding effect unobtainable in any other type of construction. These units are now being produced in practically all sections of the United States and are in great demand, particularly for single story ranch homes, although they are also used for commercial structures, store fronts and for finished masonry interiors.

When laid with a $\frac{3}{8}$" mortar joint, it requires 6 brick per sq. ft. of wall. Add for headers, breakage and waste.

When laid with a $\frac{3}{8}$" mortar joint, it requires $10\frac{3}{4}$ cu. ft. of mortar per 1,000 brick, not including any back-up mortar or any allowance for waste.

Labor Laying 1,000 Roman Face Brick, $3\frac{5}{8}$"x$1\frac{5}{8}$"x$11\frac{5}{8}$"

Common Bond				Style of Mortar Joint	Flemish Bond			
Mason Hours	Labor Hours	Hoist Engr.*	Number Laid per 8-Hr. Day		Number Laid per 8-Hr. Day	Mason Hours	Labor Hours	Hoist. Engr.*
29.6	17	0.5	250-290	Buttered and Struck	210-240	35.5	17	0.5
20.5	17	0.5	370-410	Flush Cut	300-350	24.6	17	0.5
23.5	17	0.5	320-360	V-Tooled or Concave	265-300	28.3	17	0.5
25.0	17	0.5	300-340	Struck or Weathered	245-285	30.2	17	0.5
23.5	17	0.5	320-360	Raked Out	265-300	28.3	17	0.5
26.7	17	0.5	280-320	Rodded	230-270	32.0	17	0.5

*Add hoisting engineer's time only if required

Cu. Ft. of Mortar Required to Lay 1,000 English Size Face Brick

Based on ¼" End Joints and "Bed" Joints as Given Below

⅛"	¼"	⅜"	½"	⅝"	¾"
5	9	11	14	17	20

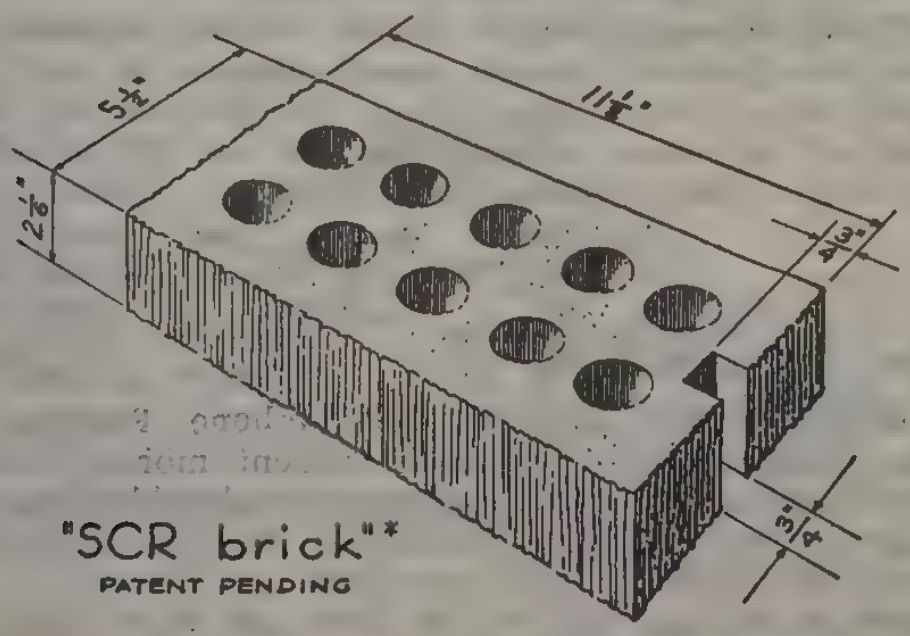
Vitrified Face Brick

There are a number of vitrified face brick on the market that are so hard it is almost impossible to cut them. On account of their denseness and brittleness they do not absorb water from the mortar and for that reason it requires more time for the mortar to take its initial set. It is impossible to lay up many courses of brick at one time because the weight of the upper brick courses forces the mortar from the joints of the lower courses, causing an unsightly wall. It is also difficult to hold the brick in the wall and keep the wall plumb, as the brick slide out of place very easily.

Brick of this kind are ordinarily laid with "buttered" mortar joints or with ¼" mortar joints struck flush. They are furnished in the standard size, 8"x2¼"x3¾", and require the same number of brick and the same amount of mortar as other standard size face brick.

SCR Face Brick

"SCR brick", developed by the Structural Clay Products Research Foundation, combines the beauty of the original Norman brick size with the utility and structural advantage of a single unit for nominal 6" masonry wall construction.



*Registered Trademark SCPRF

Designed primarily to meet the construction requirements of FHA and National Building Codes for one story, single family dwellings, where the wall height does not exceed 9'-0" to the eaves or 15'-0" to the peak of the gables.

The nominal face size of "SCR brick" is 2⅔"x12", while the actual size of the brick is 2⅛"x5½"x11½".

When laid with a ½" mortar joint, each brick lays up 32 sq. in. of wall, or it requires 4½ brick per sq. ft. of wall, not including any allowance for breakage or waste.

When laid with a ½" mortar joint, it requires approximately 34¼ cu. ft. of mortar per 1,000 brick. This quantity includes an allowance for mortar entering the cores and also provides for 10 percent waste.

Depending upon the length of walls and the number of door and window openings, a mason should lay 450 to 500 and better brick per 8-hr. day, at the following cost per 1,000:

	Hours	Rate	Total	Rate	Total
1,000 SCR brick.....		$.....	$.....	$165.00*	$165.00
34¼ cu. ft. 1:1:6 mortar..		.....	.....	.68	23.29
Mason	18	.....	.....	7.10	127.80
Labor	10	.....	.....	5.00	50.00
Cost per 1,000 brick...	28		$.....		$366.09
Cost per sq. ft. wall† (222 sq. ft.)					$1.65

†No allowance included for furring.
*Brick price varies according to locality and color.

Brick Floors and Steps

Face Brick Floors Laid in Basket Weave Pattern.—Brick floors laid in square or basket weave pattern do not require any cutting and are much easier laid than herringbone designs.

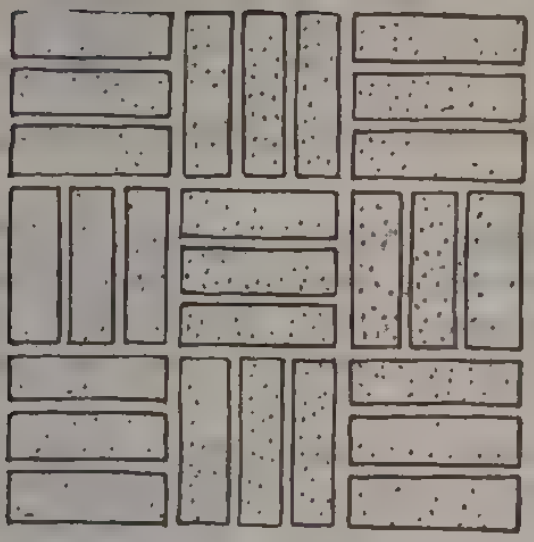
On work of this kind, a mason should lay 180 to 225 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	40	$.....	$.....	$7.10	$284.00
Labor	20	.....	.....	5.00	100.00
Cost per 1,000 brick ...	60		$.....		$384.00

Face Brick Floors Laid in Herringbone Pattern.—Brick floors are usually laid in portland cement mortar and when laid in herringbone pattern, it requires considerable time cutting and fitting the small pieces of brick at the edge or border of the pattern, as shown in the illustration.

A mason should lay 125 to 150 brick per 8-hr. day, at the following labor cost per 1,000:

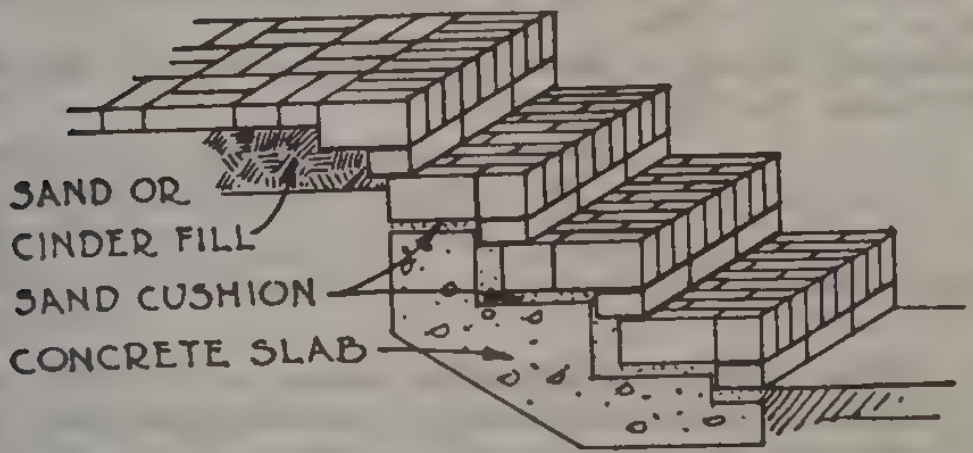
BRICK FLOOR PATTERNS



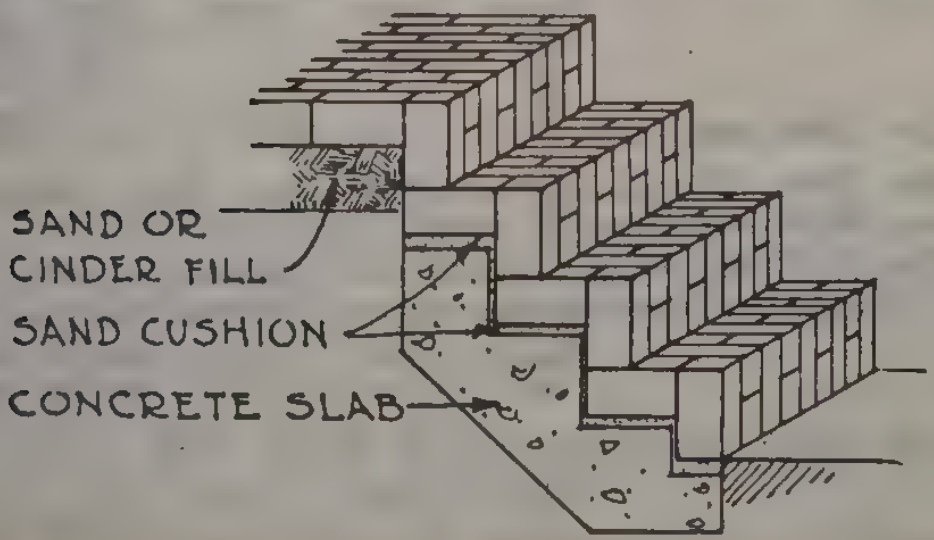
Brick Laid in Basket Weave Pattern.

Brick Laid in Herringbone Pattern.

BRICK STAIR DETAILS



Brick Steps with End-Set Treads



Brick Steps with Edge-Set Treads

	Hours	Rate	Total	Rate	Total
Mason	56	$.....	$.....	$7.10	$397.60
Labor	28	.....	.....	5.00	140.00
Cost per 1,000 brick	84		$.....		537.60

If there is only one mason on the job it will require a helper for each mason.

Promenade Tile Floor and Decks.—When laying 4½"x8" Promenade tile on porch floors and decks, with the tile laid in portland cement mortar and ½" mortar joints, struck flush, a mason should lay and point 100 to 125 tile per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	68	$.....	$.....	$7.10	$482.80
Labor	34	.....	.....	5.00	170.00
Cost per 1,000 tile	102		$.....		$652.80

A tile is 4½"x8" in size, or it requires 4 tile per sq. ft. not including mortar joints. Figuring a ½" mortar joint, it requires 3.5 tile per sq. ft. of floor.

A mason will lay 30 to 36 sq. ft. of floor per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Mason	24	$.....	$.....	$7.10	$170.40
Labor	12	.....	.....	5.00	60.00
Cost per 100 sq. ft.	36		$.....		$234.40
Cost per sq. ft.			.....		$2.34

Brick Steps.—When laying brick steps in portland cement mortar, similar to those illustrated, a mason should lay 125 to 150 brick per 8-hr. day, at the following labor cost per 1000:

	Hours	Rate	Total	Rate	Total
Mason	56	$.....	$.....	$7.10	$397.60
Labor	28	.....	.....	5.00	140.00
Cost per 1,000 brick	84		$.....		$537.60

Turning Face Brick Segmental Arches Over Doors and Windows.—Where segmental brick arches are laid over wood centers for 3'-0" wide door and window openings, it will require about 4 hrs. mason time at the following labor cost per arch:

	Hours	Rate	Total	Rate	Total
Mason	4	$.....	$.....	$7.10	$28.40

For a 5'-0" arch, figure about 6.5 hrs. mason time, as follows:

	Hours	Rate	Total	Rate	Total
Mason	6.5	$.....	$.....	$7.10	$46.15

If the brick are cut or chipped to a radius, add cost of chipping as given below.

Laying Face Brick in Flat or "Jack" Arches.—When laying face brick in flat or "Jack" arches a mason should complete one arch up to 3′-6″ wide in about 5 hrs. at the following labor cost:

	Hours	Rate	Total	Rate	Total
Mason	5	$.....	$.....	$7.10	$35.50

For a 5′-0″ "Jack" arch, figure about 7½ hrs. mason time, as follows:

	Hours	Rate	Total	Rate	Total
Mason	7.5	$.....	$.....	$7.10	$53.25

The above costs do not include chipping or rubbing brick to a radius. If this is necessary, add cost of chipping as given below.

Chipping Brick.—Where necessary to chip or cut brick for segmental or "Jack" arches, a mason should chip 400 to 500 brick per 8-hr. day, depending upon the texture and density of the brick, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	17.5	$.....	$.....	$7.10	$124.25

There is considerable lost motion in cutting brick and unless there is a great deal of duplication in the cutting where a man can work continuously on a few special sizes, a mason will cut only 160 to 200 pieces per 8-hr. day, at the following labor cost, per 100 pieces:

	Hours	Rate	Total	Rate	Total
Mason	4.5	$.....	$.....	$7.10	$31.95
Labor	1.0	.....	.....	5.00	5.00
½ blade			.....	8.00	4.00
Cost per 100 cuts	5.5		$.....		40.95
Cost per cut			.....		4.10

See cost of cutting brick under "Tools and Equipment."

Cleaning and Pointing Face Brick Work

The cost of cleaning face brick work will vary with the kind of brick, as it is much easier to clean a smooth face vitrified brick than one having a rough texture.

When estimating tuckpointing, the cost of the work may be figured either by the thousand brick or by the sq. ft. of surface. When estimating by the sq. ft. do not make deductions for door and window openings unless very large.

Where smooth face brick are used and it is not necessary to

do any pointing but merely wash the wall with muriatic acid and water, an experienced tuckpointer should clean 5,000 to 5,500 brick (750 to 825 sq. ft. of wall) per 8-hr. day, at the following labor cost per 1,000 brick, or approximately 150 sq. ft. of wall:

	Hours	Rate	Total	Rate	Total
Tuckpointer	1.6	$.....	$.....	$7.50	$12.00
Helper*	0.8	.....	.....	5.00	4.00
Cost per 1,000 brick	2.4		$.....		$16.00
Cost per sq. ft. of wall			.....		.10

If the work is sublet to a tuckpointing contractor, add for scaffolds, insurance, overhead expense and profit.

If ordinary bricklayers (who do not make a specialty of tuckpointing) are used on this work, a man should clean and wash with muriatic acid 4,000 to 4,500 brick (600 to 675 sq. ft. of wall surface) per 8-hr. day, at the following labor cost per 1,000 brick or 150 sq. ft. of wall:

	Hours	Rate	Total	Rate	Total
Bricklayer	2	$.....	$.....	$7.10	$14.20
Helper*	1	.....	.....	5.00	5.00
Cost per 1,000 brick	3		$.....		$19.20
Cost per sq. ft. of wall			.....		.128

The labor cost of cleaning and washing rough texture face brick will run higher than smooth brick on account of the cement and mortar getting into the surface of the brick.

When cleaning and washing rough textured brick, an experienced tuckpointer should clean and wash with muriatic acid and water 3,500 to 4,000 brick (525 to 600 sq. ft. of wall) per 8-hr. day, at the following labor cost per 1,000 brick or per 150 sq. ft. of wall:

	Hours	Rate	Total	Rate	Total
Tuckpointer	2.2	$.....	$.....	$7.50	$16.50
Helper*	1.1	.....	.....	5.00	5.50
Cost per 1,000 brick	3.3		$.....		$22.00
Cost per sq. ft. of wall			.....		.14

If the work is sublet to a tuckpointing contractor, add for scaffolds, insurance, overhead expense and profit.

If rough textured face brick are cleaned and washed with muriatic acid and water by ordinary bricklayers, a man should clean 2,600 to 3,000 brick (400 to 450 sq. ft. of wall) per 8-hr. day, at the following labor cost per 1,000 brick or per 150 sq. ft. of wall:

*Figure one helper on the ground to each 2 to 4 tuckpointers, or to each scaffold.

	Hours	Rate	Total	Rate	Total
Bricklayer	2.8	$.....	$.....	$7.10	$19.88
Helper*	1.4	.....	.....	5.00	7.00
Cost per 1,000 brick...	4.2		$.....		$26.88
Cost per sq. ft. of wall...			.....		.1792

* Figure one helper to each 2 to 4 tuckpointers, or to each scaffold.

4" Vitreous Face Brick Partitions.—The interior partitions in the laundry of a four story hospital building were built of Kittaning, Penna. brick. They are a light gray color, smooth texture and very hard (almost like flint), and they absorb very little water from the mortar.

These partitions were 12'-0" high and only 4" (one course of brick) thick, laid in common bond in lime mortar, with mortar joints struck flush on both sides of the wall.

This was a very difficult job of bricklaying as it was almost impossible to hold the brick in the wall.

A mason laid 408 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	19.7	$.....	$.....	$7.10	$139.87
Labor	15.0	.....	.....	5.00	75.00
Cost per 1,000 brick....	34.7		$.....		$214.87

Kittaning Brick With Struck Mortar Joints.—These are a very hard, light gray brick, and on account of their brittleness and density are very hard to cut. They absorb very little water from the mortar and are especially difficult to lay in winter weather.

There were 37,000 of these brick laid in common bond, in lime mortar with mortar joints struck flush.

A mason laid 400 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	20.0	$.....	$.....	$7.10	$142.00
Labor	12.5	.....	.....	5.00	62.50
Hoisting engineer	1.0	.....	.....	6.00	6.00
Cost per 1,000 brick....	33.5		$.....		$210.50

Face Brick Door and Window Trim.—All of the wall panels, door and window trim in the solarium of a large fireproof hospital building were constructed of impervious press brick having a smooth surface (similar to Kittaning brick). They were laid in "header" or "rowlock" courses and it required great care in addition to an unusually large amount of cutting and fitting to get the panels to work out just right, as will be noted from the illustration.

The job contained 3,200 face brick and all headers are estimated as full brick because many of them were laid in this manner.

A mason laid 300 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	26.7	$.....	$.....	$7.10	$189.57
Labor	18.8	.....	.....	5.00	94.00
Cost per 1,000 brick	45.5		$.....		$283.57

Brick Fireplaces, Mantels and Hearths

On account of the many sizes, shapes and styles of brick fireplaces, mantels and hearths, it is difficult to estimate the cost of the work at a certain price per 1,000 brick and the most satisfactory method is to figure a certain length of time to lay up each fireplace or mantel.

A mason should complete a plain brick fireplace 5′-0″ to 6′-0″ wide and 4′-0″ to 5′-0″ high, requiring 200 to 225 brick, not including hearth, in about 10 hrs. at the following labor cost:

	Hours	Rate	Total	Rate	Total
Mason	10	$.....	$.....	$7.10	$71.10
Labor	5	.....	.....	5.00	25.00
Cost per fireplace	15		$.....		$96.10

On larger and more elaborate brick fireplaces and mantels having raked or rodded mortar joints, a mason should lay about 100 to 125 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	70	$.....	$.....	$7.10	$497.00
Labor	35	.....	.....	5.00	175.00
Cost per 1,000 brick	105		$.....		$672.00

If there is only one mason working on the job it will require one laborer with each mason.

Brick Fireplace Linings.—A mason should complete the lining for a brick fireplace having an opening 3′-0″ to 4′-0″ wide, 2′-6″ to 3′-0″ high, and 1′-4″ to 1′-9″ deep, in 6 to 8 hrs. all depending upon the class of work.

If the fireplace linings are laid in common bond and do not require an excessive amount of cutting and fitting, a mason should complete one fireplace lining in about 5 hrs. but where the back-hearths are of irregular shape and require considerable cutting and fitting at angles and at tops for dampers and smoke chambers, it will require about 8 hrs. mason time for each lining.

Fireplaces having an opening 3'-6" to 4'-0" wide, about 4'-0" high and 1'-9" deep, lined with firebrick laid in herringbone pattern, requiring cutting and fitting at all edges and corners, will require 20 to 24 hrs. mason time to line one fireplace.

Labor Laying Brick Hearths and Back-Hearths.—If brick hearths and back-hearths are laid in square or basket weave pattern, a mason should complete one back-hearth in 3 to 4 hrs. and the front hearth will require the same length of time.

If laid in herringbone pattern with cut brick at all edges, figure 4 to 5 hrs. mason time for both hearth and back-hearth.

Figure about ½-hr. labor time to each hr. mason time, except where only one mason is on the job when it will figure hour for hour.

Brick Fireplace Linings and Hearths.—In a four story hospital building there were three brick fireplace linings with hearths, as illustrated on following page.

Impervious light gray brick laid in fire clay with struck mortar joints were used. There were only 100 brick in each lining but it required 9 to 10 hrs. mason time for each, as follows:

	Hours	Rate	Total	Rate	Total
Mason	10	$.....	$.....	$7.10	$71.00
Labor	6	.....	.....	5.00	30.00
Cost per lining	16		$.....		$101.00

A mason laid only 88 brick per 8-hr. day, as there was an unusually large amount of cutting and fitting at the corners of the linings.

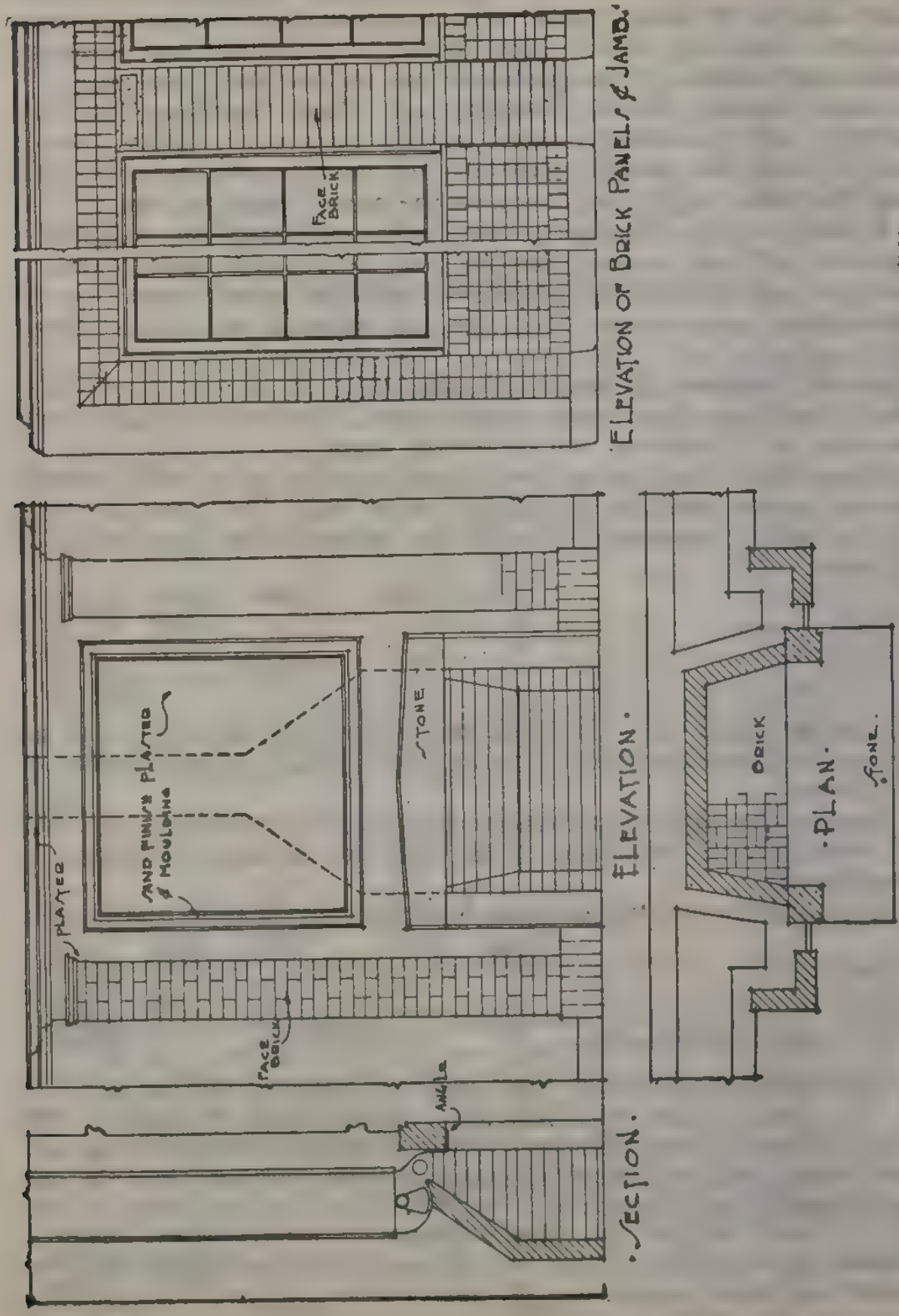
Two of the back-hearths were laid in the same kind of brick as the linings, with the brick laid in straight pattern, as illustrated.

It required 4 hrs. mason time on each back-hearth, as follows:

	Hours	Rate	Total	Rate	Total
Mason	4	$.....	$.....	$7.10	$28.40
Labor	3	.....	.....	5.00	15.00
Cost per back-hearth	7		$.....		$43.40

One hearth was laid in "herringbone" pattern, and on account of this design and the difficulty encountered in cutting the brick (it was often necessary to cut 10 brick before getting one that would cut on a line) it required 9 hrs. mason time on one back-hearth, as follows:

	Hours	Rate	Total	Rate	Total
Mason	9	$.....	$.....	$7.10	$63.90
Labor	6	.....	.....	5.00	30.00
Cost per back-hearth	15		$.....		$93.90



Details of Brick Panels, Fireplace and Hearth in a Hospital Building.

The Ideal Brick Wall

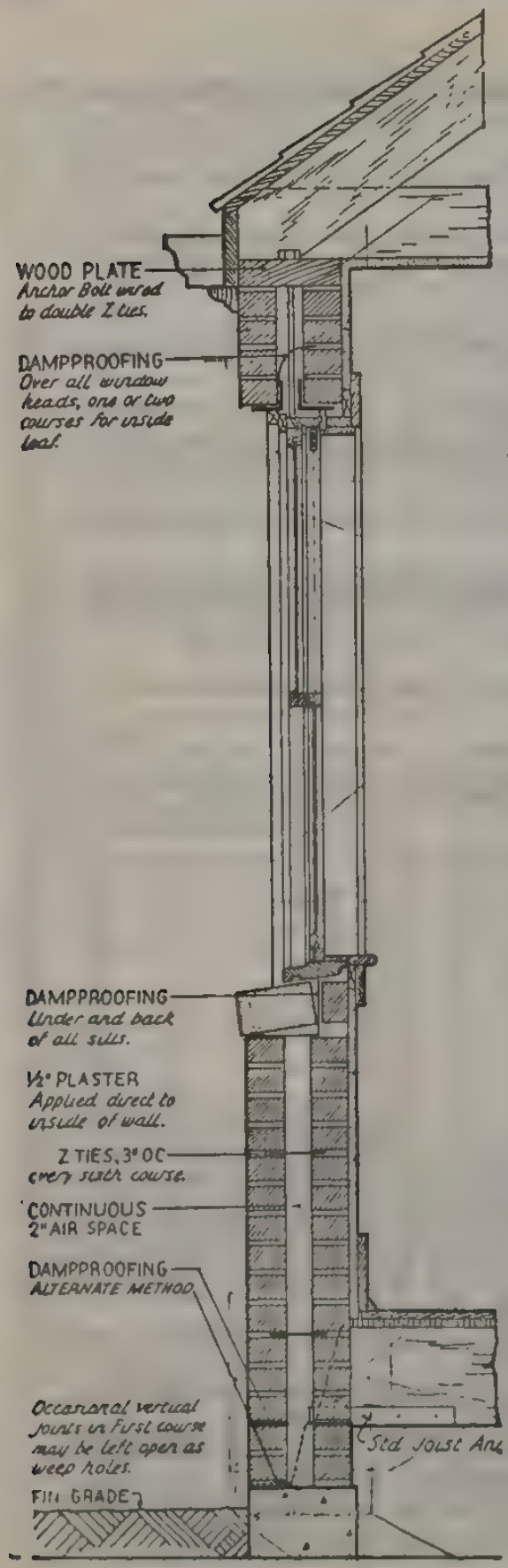
The Ideal wall is the general name used to describe all types of hollow walls built with standard solid brick. There are three types of Ideal walls, as follows: Ideal Rolok-bak walls; Ideal all-rolok walls, and Ideal all-rolok walls in Flemish Bond.

Only in the all-rolok types does the exterior appearance of the Ideal wall differ from the standard and traditional brickwork with which all are familiar. In the other type—the rolok-bak wall—the face of the wall may be worked out in any bond and joint to suit the builder's taste, and the complete wall has the same appearance as a wall of solid brickwork.

Labor Laying Common Brick in Ideal Walls

Class of Work	No. Brick per Sq. Ft. Wall	No. Laid 8-Hr. Day	Sq. Ft. Wall per 8-Hr. Day	Hours Req'd per 1,000 Brick	
				Mason	Labor
8″ Rolok-Bak, Careful Work	10.5	600	57.0	13.3	8
8″ Rolok-Bak, Rough Work	10.5	925	88.0	8.7	8
12″ Rolok-Bak, Careful Work	15	700	46.7	11.4	8
12″ Rolok-Back, Rough Work	15	1,050	70.0	7.6	8
12″ Heavy-Duty Rolok-Bak Wall, Careful Work	15.8	700	44.3	11.4	8
12″ Heavy-Duty Rolok-Bak Wall, Rough Work	15.8	950	60.0	8.4	8
8″ All-Rolok Wall, Careful Work	9	650	72.2	12.3	8
8″ All-Rolok Wall, Rough Work	9	750	83.4	10.6	8
12″ All-Rolok Wall, Careful Work	13.5	700	51.8	11.4	8
12″ All-Rolok Wall, Rough Work	13.5	1,000	74.0	8.0	8
8″ All-Rolok Wall, Flemish Bond	9	450	50.0	17.8	8
12″ All-Rolok Wall, Flemish Bond	13.75	550	40.0	14.5	8
12″ All-Rolok Wall, Flemish Bond, Rough Work	13.75	700	51.0	11.4	8

*Add for hoisting engineer if brick are to be hoisted above the first story.


WOOD PLATE
Anchor Bolt wired to double Z ties.
DAMPPROOFING
Over all window heads, one or two courses for inside leaf.
DAMPPROOFING
Under and back of all sills.
½" PLASTER
Applied direct to inside of wall.
Z TIES, 3' OC
every sixth course.
CONTINUOUS
2" AIR SPACE
DAMPPROOFING
ALTERNATE METHOD
Occasional vertical joints in First course may be left open as weep holes.
FIN GRADE
Std Joist An

Brick Cavity Wall Construction

Brick Cavity Walls.—Brick cavity walls are distinguished from all other forms of hollow masonry by a continuous, vertical and horizontal air space, bridged by no masonry ties. Prime purpose of this space is to provide an absolute barrier against the penetration of moisture to the inner side of the wall at any point, including heads and jambs of openings, joist bearing points, etc., thus assuring trouble-free masonry and permitting direct plastering without furring. It also increases resistance to heat-flow to about the same extent as the air space created by ordinary furring.

Since this construction affords no supporting material through which moisture penetrating the outer 4" wythe of the wall can soak to the inner wythe, it guarantees the inner wythe will remain perfectly dry, provided adequate precautions are taken to intercept and deflect moisture running down the inner side of the outer wythe at the heads of all openings, and provided the bottom of the wall is equipped with a suitable dampproof course to prevent absorption of soil water.

In place of the usual header courses, the inner and outer wythes of the cavity walls are connected by rust-proof metal ties —usually 3/16" diameter, square-end, Z bars—placed in every sixth course and 3'-0" on center horizontally.

The labor cost of cavity walls varies according to the length of the walls, thickness, etc. A 10"

cavity wall, consisting of two 4" walls with a 2" air space, should cost about 20 percent more than an 8" solid wall. A 14" cavity wall, consisting of one 4" wall and one 8" wall with a 2" air space, should cost approximately 10 percent more than a solid 12" wall of comparable length and height.

Brick Catch Basins, Cesspools and Manholes

When laying common or sewer brick in catch basins, manholes, cesspools, etc., from 3'-0" to 5'-0" in diameter and having 8" to 12" walls, a mason should lay 600 to 750 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	11.5	$.....	$.....	$7.10	$81.65
Labor	11.5	.....	.....	5.00	57.50
Cost per 1,000 brick	23		$.....		$139.15

FIRE BRICK WORK

Fire brick and tile are furnished in innumerable sizes and shapes to meet the requirements of all classes of boilers, furnaces, stacks, etc., so that it is practically impossible to list them all in this book. The most common sizes and shapes are listed below. Standard fire brick size is 9"x4½"x2½" and will cost around $190.00 per 1000.

Sizes and Shapes of Standard Fire Brick

Name	Size	Number Required per Sq. Ft. Laid Flat	Laid on Edge
8" Straight	8"x3½"x2¼"	8.0	5.2
9" Straight	9"x4½"x2½"	6.5	3.5
Small 9" Brick	9"x3½"x2½"	6.5	4.5
Split Brick	9"x4½"x1¼"	13.0	3.5
2" Brick	9"x4½"x2 "	8.0	3.5
Soap	9"x2¼"x2½"	6.5	7.0
Checker	9"x2¾"x2¾"	6.0	6.0

Fire Clay.—When a close thin joint is desired, the clay should be soaked and mixed thin, and the brick should be dipped and

rubbed. For work of this kind 300 lbs. of finely ground fire clay is required per 1,000 brick.

Ordinary fire clay costs about $1.50 per 100 lbs. while high-grade refractory fire clay costs about $2.00 per 100 lbs.

Labor Lining Brick Chimneys and Stacks with Fire Brick.—When lining small brick chimneys and stacks from 2'-0" to 3'-0" square, laid in fire clay, a mason should lay 450 to 525 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	16	$.....	$.....	$7.10	$113.60
Labor	12	.....	.....	5.00	60.00
Cost per 1,000 brick	28		$.....		$173.60

On large brick stacks having an inside diameter of 4'-0" to 6'-0", a mason should lay 600 to 750 fire brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	11.8	$.....	$.....	$7.10	$83.78
Labor	10.0	.....	.....	5.00	50.00
Cost per 1,000 brick	21.8		$.....		$133.78

Number of Wedge and Arch Brick Required for Various Circles

No. 1 Wedge Brick 9"x4½"x (2½"-1⅞")

No. 2 Wedge Brick 9"x4½"x (2⅛"-1½")

No. 1 Arch Brick 9"x4½"x (2½"-2⅛")

No. 2 Arch Brick 9"x4½"x (2½"-1¾")

Labor Laying Fire Brick in Fireboxes, Breechings, Etc.—When lining fireboxes, breechings, furnaces, etc., with fire brick, requiring arch and radial brick, special shapes, etc., a mason should lay 175 to 225 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	40	$.....	$.....	$7.10	$284.00
Labor	40	.....	.....	5.00	200.00
Cost per 1,000 brick	80		$.....		$484.00

Table of Wedge Brick Required for Various Circles **Number of Arch Bricks Required for Various Circles**

Diam. Ft.	Diam. In.	No. 2 Wedge	No. 1 Wedge	Square	Total	No. 2 Arch	No. 1 Arch	9-inch	Total
2	0	.....	.....	.....	.....	42	.....	.....	42
2	6	63.	.....	.....	63.	10	40	.....	50
3	0	48.	20.	.....	68.	.....	57	.....	57
3	6	36.	39.	.....	75.	.....	57	7	64
4	0	24.	57.	.....	81.	.....	57	15	72
4	6	12.	78.	.....	90.	.....	57	22	79
5	0	.....	94.	.....	94.	.....	57	29	86
5	6	.....	94.	7.5	102.	.....	57	37	94
6	0	.....	94.	15.	109.	.....	57	44	101
6	6	.....	94.	23.	117.	.....	57	52	109
7	0	.....	94.	30.	124.	.....	57	59	116
7	6	.....	94.	39.	133.	.....	57	67	124
8	0	.....	94.	45.	139.	.....	57	74	131
8	6	.....	94.	53.	147.	.....	57	82	139
9	0	.....	94.	60.	154.	.....	57	89	146
9	6	.....	94.	68.	162.	.....	57	97	154
10	0	.....	94.	75.	169.	.....	57	104	161

When estimating brick arches, it is advisable to allow additional labor and it is doubtful if a mason thoroughly experienced in boiler work will average more than 25 brick an hour for the actual arch and skew-backs, due to adverse conditions, close working space, etc. One contractor specializing in this class of work, checks the penetrations through the wall and regardless of size, adds 4 hours mason time for each one.

Labor Bricking in Boilers.—When bricking in steel boilers, fireboxes, breechings, etc., with common or fire brick where the walls are 8″ to 12″ thick, a mason should lay 600 to 650 brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Mason	13	$.....	$.....	$7.10	$92.30
Labor	13	.....	.....	5.00	65.00
Cost per 1,000 brick	26		$.....		$157.30

Fire Clay Tile Flue Lining

Flue lining is estimated by the lin. ft. It is furnished in 2'-0" lengths in the following sizes:

Size of Flue Lining	No. Lin. Ft. Set per 8-Hr. Day	Hrs. Required to Set 100 Lin. Ft. Mason	Labor
4"x 8"	165-180	4.7	4.7
4"x12"	130-150	5.7	5.7
8"x 8"	130-150	5.7	5.7
8"x12"	105-125	7.0	7.0
12"x12"	85-100	8.7	8.7
8"x18"	75- 90	9.7	9.7
12"x18"	70- 85	10.2	10.2
18"x18"	60- 70	12.3	12.3
20"x20"	55- 65	13.3	13.3
20"x24"	50- 60	14.0	14.0
24"x24"	45- 55	16.0	16.0
20" round	55- 65	13.3	13.3

Approximate Prices of Tile Flue Lining

Size	Price Lin. Ft.	Size	Price Lin. Ft.
8½"x8½"	$0.75	6" Round	$0.61
8½"x13"	1.10	8" Round	.96
13" x13"	1.41	10" Round	1.43
13" x18"	2.28	12" Round	1.84
18" x18"	2.93	15" Round	2.92
20" x20"	5.25	18" Round	4.15
20" x24"	6.05	20" Round	4.86
24" x24"	6.80	24" Round	8.00

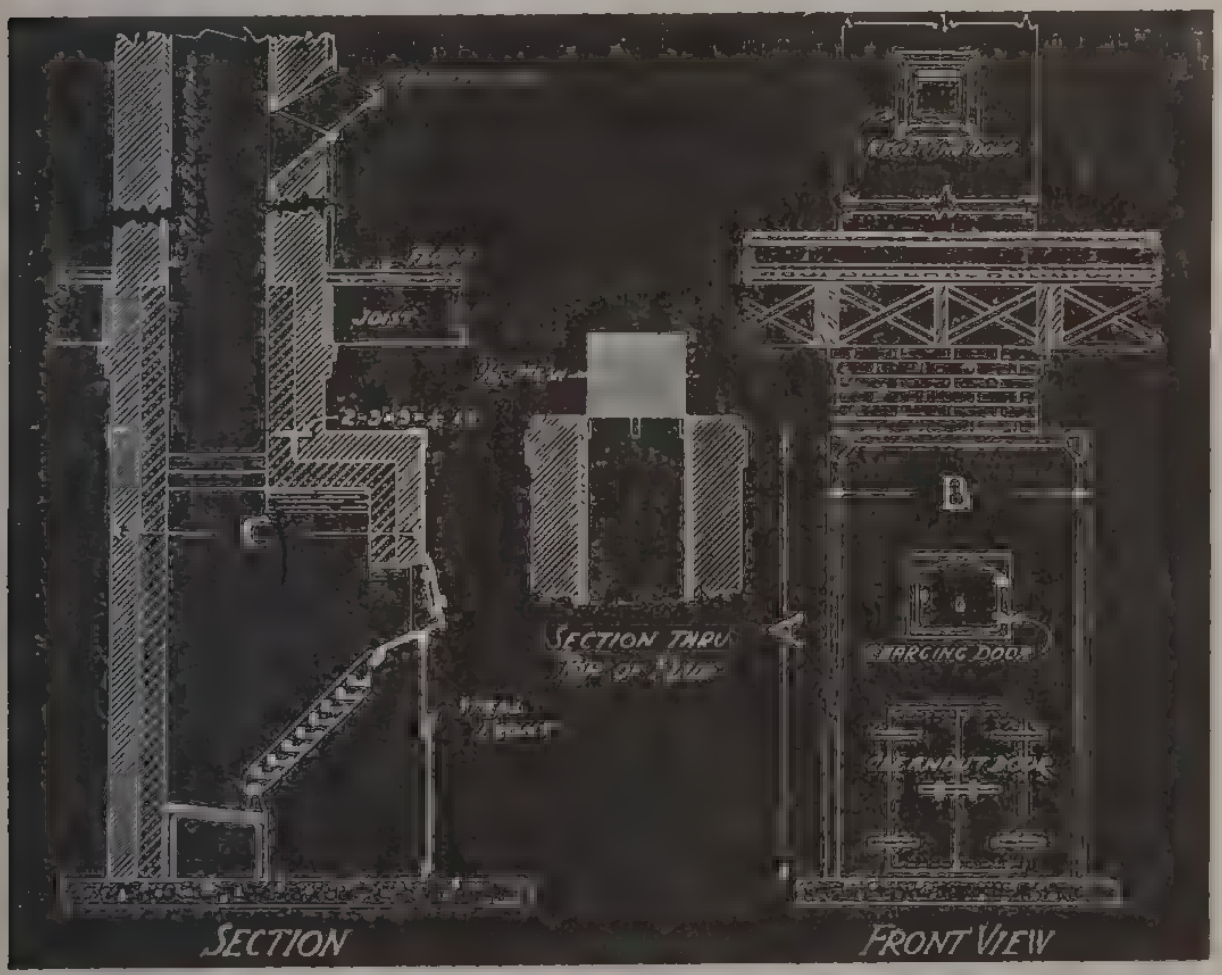
Labor Setting Salt Glazed Wall Coping

Size of Coping	No. Lin. Ft. Set per 8-Hr. Day	Hrs. Required to Set 100 Lin. Ft. Mason	Labor
9"	145-160	5.2	5.2
12"	115-130	6.5	6.5
18"	100-120	7.3	7.3

Approximate Lineal Foot Prices of Salt Glazed Wall Coping

Size	Double Slant	Single Slant	Lap-Lock
9"	$0.58	$1.16	$0.67
13"	.86	1.74	1.00
18"	1.75	3.48	2.00

Corners, ends and starters, four times price of straight coping; angles, six times the price of straight coping.



Illustrating Construction of One Type of Brick Incinerator

Brickwork for Incinerators

Incinerators are used in residences, apartments, apartment hotels, hotels, hospitals, schools, industrial plants, etc., for burning garbage, waste papers, etc.

With many types the refuse may be fed into the chimney at each floor, the deposited material dropping to the incinerator in the basement, or they may be fed direct to the incinerator in the basement.

Practically all incinerators require a separate flue or stack,

which should be estimated in the regular way, figuring fire brick, flue lining and common brick as shown on the plans.

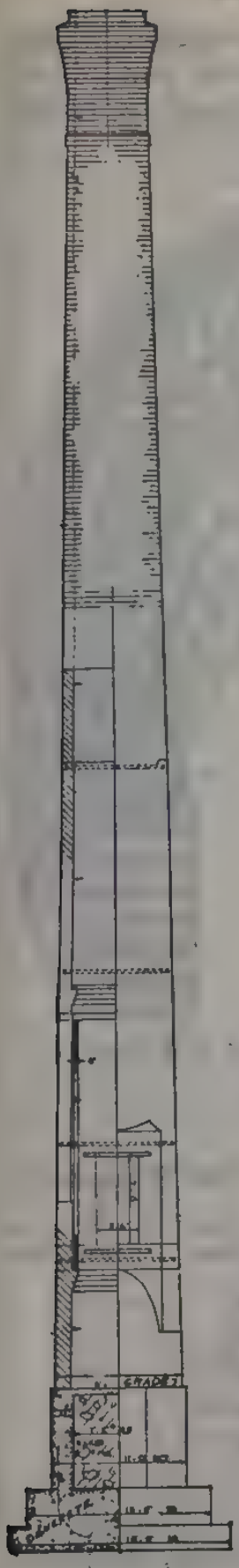
The number of fire and common brick required for the various sizes and types of incinerators will vary with the different manufacturers.

However, the following data will assist the estimator in computing the number of brick and labor hours required to construct the brickwork for the different size incinerators, where they are not detailed on the plans.

Model	Capacities Rated By Apartments		
"A"	Residences—2 and 3 Flat Buildings		
"B"	Up to 20 Studio Apartments	Up to Apartments of 5 or 6 Rooms Each	Up to Eight 10-Room Apartments
"C"	Up to 70 Studio Apartments	Up to 40 Apartments of 5 or 6 Rooms Each	Up to 20 Apartments of 10 Rooms Each
"D"	Up to 125 Studio Apartments	Up to 60 Apartments of 5 or 6 Rooms Each	For Institutions where not more than 125 lbs. per hour is burned

NOTE—If 4" outside walls are used, dimensions above will be reduced in length and height by 4" and in width by 8".

Model	Dimensions			Number Brick		Minimum Size Flue	Mason Hours	Labor Hours
	A	B	C	Fire	Common			
"A"	6′ 0″	3′ 5″	4′ 0″	300	900	12″x12″	20	14
"B"	5′ 7″	3′ 11″	4′ 7½″	350	1100	14″x14″	24	18
"C"	6′ 0″	4′ 3″	4′ 7½″	400	1300	16″x16″	28	20
"D"	6′ 10″	4′ 3″	5′ 11″	525	1500	20″x20″	33	24



Radial Brick Chimney

RADIAL BRICK CHIMNEYS

The construction of radial brick chimneys is a highly specialized business and they are usually constructed by contractors specializing in chimney construction.

They have in their employ workmen with years of experience in this class of work and can build them much more economically than the contractor who has just an occasional chimney to build. Also, most constructors of radial brick chimneys have their own designs and shapes of radial brick, manufactured especially for them, so they are not available to the average contractor.

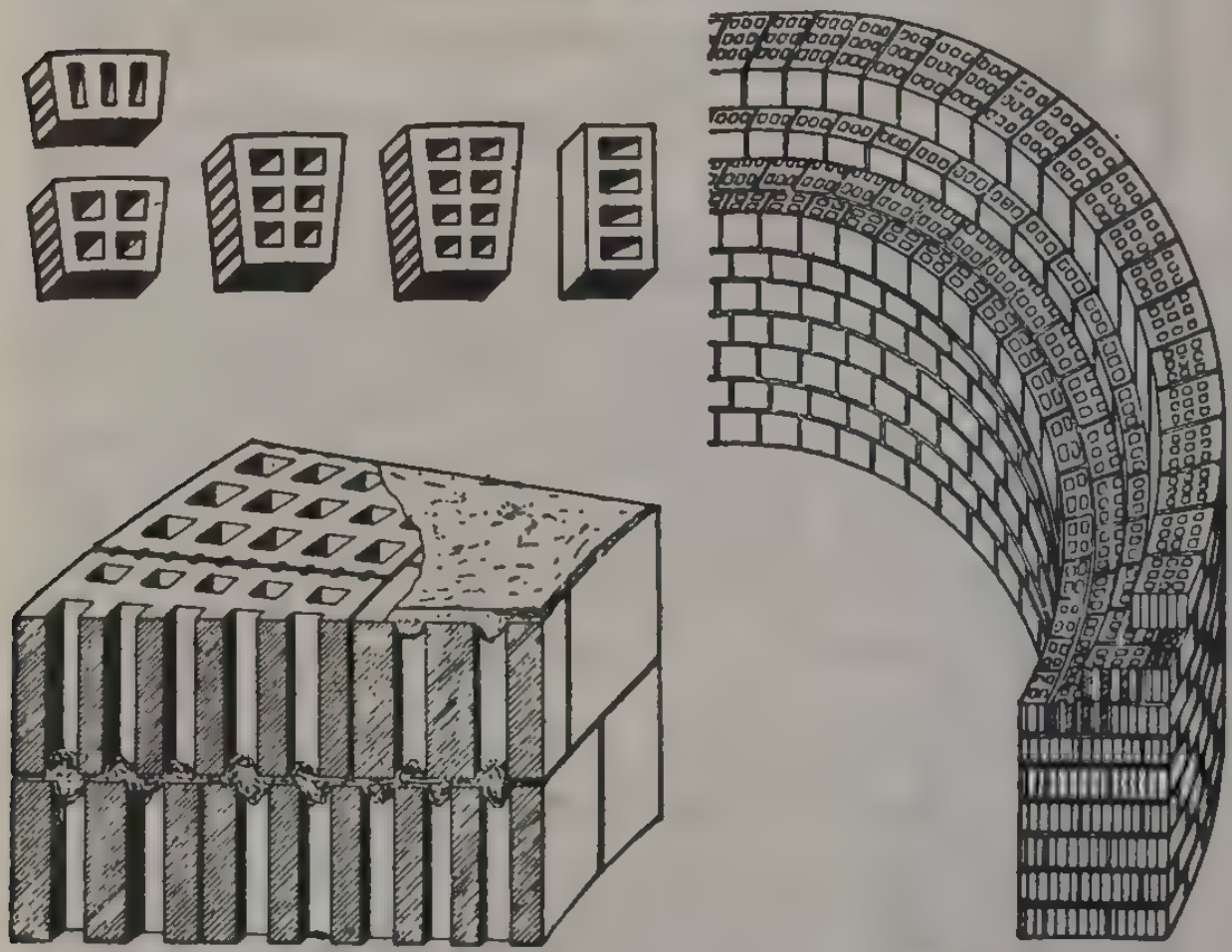
However, some information on this important subject may be of value to many contractors. Radial brick chimneys are constructed of perforated radial brick formed to fit the circular and radial lines of the chimney. The brick are moulded with vertical perforations, and should be hard, well burned, acid proof, of necessary refractory powers and crushing strength and of maximum density. They are usually built to taper ¼" to each 1'-0" in height.

The perforations serve to form a dead air space in the walls of the chimney which tends to prevent rapid heating and cooling of the walls by conserving the heat inside. Naturally, the higher the temperature of the gases the better the draft.

Four sizes of brick are ordinarily used in the construction of radial brick chimneys. All have the same face dimensions, approximately 6½" wide by 4½" high. The lengths of the blocks vary in order to make possible the breaking of the joints horizontally and vertically in the walls. The combination of bonds with this type of chimney provides for a lighter chimney than can be produced with ordinary building brick.

Radial chimney brick are generally either red or buff in color. Red radial brick are usually the most economical, as they are in greater demand and there are more sources of supply.

In laying the brick, the mortar is worked into the perforations, locking them together on the principle of a mortise and tenon joint. This produces the strongest bonded wall known to brick construction.



Perforated Radial Chimney Brick and Details of Bonding and Jointing of Perforated Radial Brick Construction.

Sizes and Weights of Radial Brick for Radial Brick Chimneys

Type Brick	Outside Face	Inside Face	Depth Inches	Height Inches	Weight Pounds
No. 4	6½″	5¾″	4″	4½″	7
No. 6	6½″	5½″	6″	4½″	9½
No. 7	6½″	5½″	7″	4½″	11
No. 8	6½″	5½″	8″	4½″	12
Pier	9″	9″	4″	4½″	9

Each radial brick having an outside face 6½″ wide and 4½″ high covers 29¼ sq. in. of surface, or it requires (4.923) 5 blocks per sq. ft. of wall, not including mortar joints. Allowing ½″ for

mortar joints, each brick covers 7″x5″ or 35 sq. in. of surface, or it requires 4.12 blocks per sq. ft. of wall. Add about 5 percent for breakage and waste.

The walls of most radial chimneys taper about ¼″ per 1′-0″ in height, and the thickness of the walls vary from the bottom to the top, depending upon the height. The wall thickness must be made up of a number of different depth units to provide the proper bond and structural strength. For instance a wall 16¼″ thick might be made up of 1 block 7″ deep and 2 blocks 4″ deep; a wall 8⅝″ thick of 2 blocks 4″ deep, etc.

Estimating Quantities of Radial Brick.—Radial brick chimney work is frequently estimated by the ton, inasmuch as the wall thicknesses vary, depending upon the height. A chimney 125′-0″ high might have walls of the following thicknesses:

First	25′ height, 16¼″ thick	Fourth	20′ height, 10¼″ thick
Second	20′ height, 13¼″ thick	Fifth	20′ height, 8⅝″ thick
Third	20′ height, 11¾″ thick	Top	20′ height, 7⅛″ thick

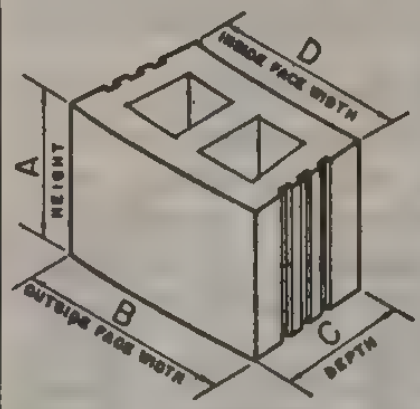
These wall thicknesses will be made up of radial brick of different depths to work out the correct wall thickness and proper bond, as follows:

Wall Thickness	Size of Units Used	Weight 29¼ Sq. In. Wall*	Weight per Sq. Ft. Wall*
20″-21″	2 pcs. 8″; 1 pc. 4″	31 lbs.	128 lbs.
18″-19″	2 pcs. 7″; 1 pc. 4″	29 lbs.	120 lbs.
16″-17″	2 pcs. 6″; 1 pc. 4″ or 2 pcs. 8″	24-26 lbs.	99-107 lbs.
14″-15″	1 pc. 6″; 2 pcs. 4″ or 2 pcs. 7″	22-23½ lbs.	91- 97 lbs.
12″-13″	1 pc. 7″; 1 pc. 4″ or 1 pc. 8″; 1 pc. 4″	18-19 lbs.	75- 79 lbs.
10″-11″	1 pc. 6″; 1 pc. 4″	16½ lbs.	68 lbs.
8″- 9″	2pcs. 4″ or 1 pc. 8″	12-14 lbs.	50- 58 lbs.
7″- 8″	1 pc. 7″ or 1 pc. 8″	11-12 lbs.	45½-50 lbs.

*Net weight of brick. Does not include mortar.

Figure radial brick chimney lining at about 30 lbs. per sq. ft. of wall surface.

Mortar Required Laying Radial Brick.—It requires about two-thirds (1,334 lbs.) of a ton of mortar to lay one ton of radial brick. Mortar is usually mixed in the proportions of 1 volume portland cement; 1 volume lime putty and 4 to 6 volumes clean mortar sand.



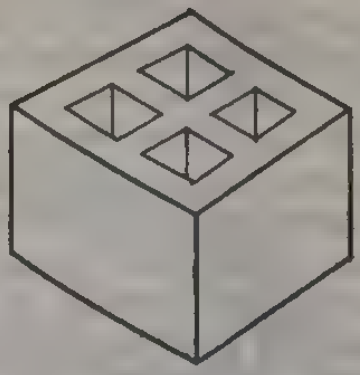
No. 4 (N)

NOTE

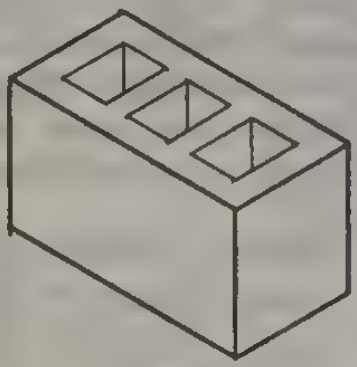
S.R. (SMALL RADIUS) UNITS EFFECTED BY ADJUSTING DIMENSION "D" TO CONFORM TO SEGMENT OF SHORTER RADIUS. FACE CURVATURE FOR BOTH STANDARD AND S.R. UNITS ARE THE SAME RESPECTIVELY AND BASED ON ARC FOR STANDARD INSIDE AND OUTSIDE RADIUS.

SIDE SCORING ON NO. 6, 7, 8, UNITS SIMILIAR TO NO. 4.

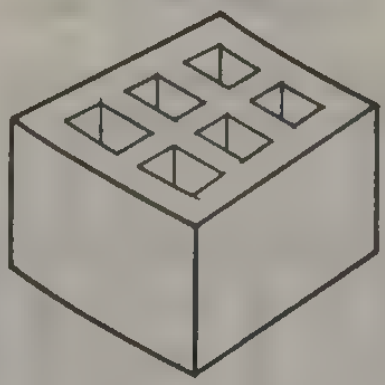
NO. 5 UNIT SMOOTH ALL FOUR SIDES.



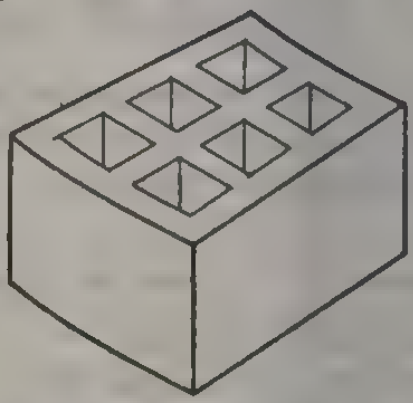
No. 6 (A)



No. S (S)



No. 7 (B) AND 7-S.R (B-S.R.)



No. 8 (C) AND 8-S.R. (C-S.R.)

UNIT	A	B	C	D	INSIDE RADIUS	APPROXIMATE SHIPPING WEIGHT	APPROXIMATE PERCENT VOIDS
4 (N)	4½"	6½"	4"	5 29/32"	3'-4"	5.5	32
6 (A)	4½"	6½"	6"	5 21/32"	3'-4"	8.3	32
7 (B)	4½"	6½"	7"	5½"	3'-8"	9.7	32
7-S.R.(B-S.R.)	4½"	6½"	7"	4 19/16"	2'-0"	9.7	32
8 (C)	4½"	6½"	8"	5½"	3'-9"	10.8	32
8-S.R.(C-S.R.)	4½"	6½"	8"	5 1/16"	2'-6"	10.8	32
S (S)	4½"	8"	4"	8"	STRAIGHT	7.0	32

Types and Sizes of Brick for Radial Brick Chimneys

Prices of Radial Chimney Brick.—The price of radial chimney brick will vary with type of brick, location of plant, freight, trucking, etc., but at the present time one midwest manufacturer's price is $18.00 per ton, f.o.b. factory. Add freight and trucking from factory to job and unloading brick at job.

One cu. yd. of 1:1:6 mortar should cost as follows:

	Rate	Total	Rate	Total
4.5 cu. ft. portland cement	$.....	$.....	$1.60	$ 7.20
4.5 cu. ft. hydrated lime...	.....	.....	.785	3.53
1 cu. yd. sand			4.05	4.05
Cost per cu. yd.		$.....		$14.78
Cost per cu. ft.				.548
Cost 0.67 ton (13.5 cu. ft.)		.....		$7.39

Labor Laying Brick in Radial Brick Chimneys.—The labor cost of laying radial brick chimneys will vary with the height of the chimney, thickness of walls, etc., but the following are actual costs on 7 radial brick chimneys recently constructed.

Description	Tons Radial Brick	Hours per Ton of Brick Mason Labor	Hoist Engr.
125′-0″ high, Walls 16½″ to 7⅛″ thick. 12′-9″ diam. at bottom, 7′-0″ at top. Lined 50′-0″....	157	2.7	4.7 0.9
80′-0″ high, walls 11¾″ to 7⅛″ thick. 8′-10″ diam. at bottom, 5′-9″ at top. Lined 35′-0″....	66.5	3.1	5.3 1.0
60′-0″ high, walls 10½″ to 7⅛″ thick. 7′-2″ diam. at bottom, 4′-4″ at top. Lined 21′-0″....	31.1	4.7	8.2 1.9
46′-0″ high, walls 10½″ to 7⅛″ thick. 6′-6″ diam. at bottom, 4′-2″ at top. Unlined.....	24.6	3.3	8.0 1.5
46′-0″ high, walls 10½″ to 7⅛″ thick. 6′-6″ diam. at bottom, 4′-2″ at top. Unlined (2)...	49.2	3.0	5.0 1.5
55′-0″ high, walls 10½″ to 7⅛″ thick. 6′-11″ diam. at bottom, 4′-2″ at top. Lined 20′-0″....	31.6	3.0	5.0 1.5

The above costs do not include supervision.

Labor time includes unloading materials from cars into trucks and unloading trucks at site.

All mortar joints on the above stacks were struck flush with point of trowel.

Where stacks are lined, labor includes lining same with perforated radial fire clay brick, laid in high temperature cement. The lining is laid up from inside after stack is topped out.

Add for clean-out doors, band iron, ladders, lightning rods, cables and cable clips.

Labor Costs on High Buildings.—On buildings over 10 to 12 stories high, it will be necessary to add an extra allowance for labor handling and hoisting the bricks and mortar, as the higher the building the longer it takes the hoist to make a trip from the street level to the floor on which the bricks are being laid and return; extra work raising and handling scaffolding, etc.

Taking a 12-story building or 120 ft. in height as normal, or 100 percent, add about 1 percent to the labor cost for each story or each 10 feet in height above 120 ft.

For instance, a 12-story building or 120 feet in height is 100, the 13th story would be 101; the 14th story, 102; the 15th story, 103, etc.

To find the average labor cost on a 15 story building, figure as follows:

The first 12 stories as 100 each or	1,200
The 13th story as 101	101
The 14th story as 102	102
The 15th story as 103	103
Total for 15 stories or 150 ft. in height	1,506

Dividing 1,506 by 15 gives 1.004 as the average cost of the masonry labor for a 15 story building. Other story heights would be computed in the same manner.

The following table applies to all classes of masonry work on high structures.

Height Stories	Normal Base	Add Above Normal %	Average for Job
1-12	100.00	None	100.00
13	100.00	1%	100.08
14	100.00	2%	100.22
15	100.00	3%	100.40
16	100.00	4%	100.63
18	100.00	6%	101.17
20	100.00	8%	101.80
22	100.00	10%	102.50
24	100.00	12%	103.25
26	100.00	14%	104.04
28	100.00	16%	104.86
30	100.00	18%	105.70
40	100.00	28%	110.15
50	100.00	38%	114.82

Miscellaneous Masonry Costs

Unloading Building Brick From Cars.—All of the building brick used to construct a large hospital were delivered to the job in cars. They were loaded into wheelbarrows and wheeled to the building about 170 ft. distant.

There were 600,000 brick in the job and a man unloaded from cars and dumped on piles about 6,400 brick per 8-hr. day, at the following labor costs per 1,000:

	Hours	Rate	Total	Rate	Total
Labor	1.25	$.....	$.....	$5.00	$6.25

Unloading Face Brick From Cars.—There were 260,000 face brick in the above job, which were unloaded from cars and placed in piles on the premises.

A laborer unloaded, wheeled and piled about 2,800 face brick per 8-hr. day, at the following labor cost per 1,000:

	Hours	Rate	Total	Rate	Total
Labor	2.9	$.....	$.....	$5.00	$14.50

Hoisting Brick and Mortar.—On the above job it was necessary to hoist about 400,000 face and building brick, together with sufficient mortar to lay them, and the labor cost per 1,000 brick was as follows:

	Hours	Rate	Total	Rate	Total
Hoisting engineer	0.7	$.....	$.....	$6.00	$4.20

Pointing Around Steel Sash With Cement Mortar.—All of the steel windows in a three story office building were pointed with portland cement mortar between the sash and the brick jambs after they had been set.

There were 39 windows 4'-0"x4'-10" and 96 windows 4'-0"x 7'-0", making a total of 2,800 lin. ft. which were pointed at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Bricklayer	1.1	$.....	$.....	$7.10	$7.81
Labor	0.5	.....	.....	$5.00	2.50
Cost per 100 lin. ft.	1.6		$.....		$10.31
Cost per lin. ft.					.103

The labor cost per window was as follows:

	Hours	Rate	Total	Rate	Total
Bricklayer	0.25	$.....	$.....	$7.10	$1.775
Labor	0.13	.....	.....	5.00	.65
Cost per window	0.38		$.....		$2.425

Plastering old Brick Walls and Blocking off to Represent Face Brick.—It is an expensive job to plaster over old building brick and block it off to represent face brick.

While the material cost is insignificant, the labor costs run high, as it is necessary to use experienced tuckpointers.

Cement mortar should be used and may be of any color to represent face brick. It should not be applied over $\frac{1}{8}$" thick. The mortar joints are then worked in, being either white or a color that shows a contrast between the brick and the mortar. The mortar joints are usually made to project a little beyond the face of the brickwork.

The labor cost of making mortar is expensive because it must be made in small quantities by the tuckpointers themselves. It is mixed, worked up, and then allowed to stand to season, and just before using it is worked up again.

After the mortar has been made, a tuckpointer should complete 125 to 150 sq. ft. of wall per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
1 bag portland cement....		$.....	$.....	$1.80	$ 1.80
1.5 cu. ft. sand		.....	.....	.15	.225
4 lbs. concentrated color		.....	.....	.30*	1.20
Tuckpointer (mortar)	6.5	.....	.....	7.50	48.75
Tuckpointer	6.5	.....	.....	7.50	48.75
Cost per 100 sq. ft....	13.0		$.....		$100.725
Cost per sq. ft.....					1.007

*Varies with color used.

If sublet to a tuckpointing contractor, add for cartage, tools, mortar, scaffolding, insurance, overhead expense and profit.

Cutting out Mortar Joints in Old Brickwork Using an Electric Grinder.—On old buildings where it is necessary to cut out the mortar joints in the old brickwork to a depth of $\frac{1}{2}$" and repoint same, the most efficient method of performing this work is to use an electrically operated carborundum wheel about 5" in diameter and $\frac{1}{4}$" thick, depending upon the width of the mortar joints. The motor is hung above the scaffolding with a flexible shaft connected to the carborundum wheel.

This method is nearly twice as fast as using an ordinary electric hand saw on account of the weight of the saw (approximately 17 lbs.) which is difficult and awkward to handle by men working on a swinging scaffold.

Either two or four men work off of each scaffold, depending upon the size of the job, and it will require one helper on the ground to each scaffold.

An experienced tuckpointer or operator should grind out lime or lime-cement mortar joints in 350 to 450 sq. ft. of brick wall per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Tuckpointer	2.0	$.....	$.....	$7.50	$15.00
Helper	1.0	$.....	$.....	5.00	5.00
Cost per 100 sq. ft.	3.0		$.....		$20.00
Cost per sq. ft.					.20

Using ordinary methods, with an electric saw or grinder, a mason will cut out about 25 sq. ft. of joints an hr. at the follcwing labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Mason	4	$.....	$.....	$7.10	$28.40
Cost per sq. ft.					.28

If sublet to a tuckpointing contractor, add for cartage, power, tools, scaffolding, insurance, overhead expense and profit.

Repointing Mortar Joints in Old Brickwork.—After the mortar joints have been cut out, two tuckpointers working on the scaffold, with one helper on the ground should point 400 to 500 sq. ft. of brick wall per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Tuckpointers	3.5	$....5	$.....	$7.50	$26.25
Helper	1.5	.....	.....	5.00	7.50
Cost per 100 sq. ft.	5.0		$.....		$33.75
Cost per sq. ft.			.....		.34

If sublet to a tuckpointing contractor, add for cartage, tools, mortar, scaffolding, insurance, overhead expense and profit.

The ordinary hanging or swinging scaffold is 25 ft. long and the men working off of each scaffold can cover approximately 6 feet in height, so that each lift of the scaffold covers 150 sq. ft.

Reinforced Brick Masonry

Reinforced brick masonry has been widely used on the west coast because of its resistance to the lateral forces produced by earthquakes. It is now also being used throughout the country where high winds or blast conditions may occur, as well as for lintels and retaining walls.

These walls are comparable to reinforced concrete construction with the masonry units serving as a form. The exterior wythes are built up in a conventional manner, the reinforcing is set in the interior joints and the whole is made homogeneous by filling the interior joints with grout.

No special skills or techniques are needed on the part of the mason, but certain care must be taken, including seeing that there

is adequate lime in the mortar; a sound base to start on with the aggregate in concrete exposed and wetted to saturation; that brick is wetted so grout will not dry out too quickly; that grout is sufficiently fluid so none will adhere to a trowel; that grout be poured in a layer of about three bricks high and be allowed to set for 15 minutes before another pour is made, and poured from the inside to avoid splashing the exposed surfaces; and that mortar cuts not be spilled into grout or grout allowed to accumulate on bed joints.

The amount of reinforcing will vary widely with the job. In lightly reinforced walls the reinforcing will fit within the widths of normal brick walls. The more heavily reinforced walls may require wider inner joints or the use of soap courses to accommodate the steel. As headers are not used in reinforced walls, the contractor should check the drawings to see if, for aesthetic reasons, header rows are shown as this will require cutting all these brick. This is especially true when figuring reinforced lintels in conventional walls so coursing can carry through.

Otherwise, lightly reinforced walls can be figured much as well constructed conventional walls. On a large hospital job recently completed in California of reinforced brick masonry, 13 masons working 7 consecutive days laid an average of 880 bricks per man day.

As compared to equivalent reinforced concrete walls, lightly reinforced brick walls will run 10 to 20 percent less. Heavily reinforced brick and concrete will run approximately the same.

Savings, as well as aesthetic advantages, can be realized often through the use of reinforced brick lintels. These are almost always poured in place with temporary shoring for the soffit. The economies result from savings in steel cost and elimination of painting. In better work it may call for the soffit brick joints to be filled temporarily with sand and then repointed later.

A variation on the above has been developed and is known as high lift grouted reinforced brick masonry. It varies in that it is essentially a cavity wall with a 2″ or better inner joint. This allows the reinforcing to be preset and grouting delayed until a full 12′ wall height is reached. Mechanical pumping can thus be used.

Precautions listed for standard reinforced walls also apply here with the following additions. Care must be taken to allow cleaning out of grout space by omitting every other unit on one side; brick must be allowed to set for at least 3 days before grouting; vibrating of grout is necessary; once grout pour is started, it must be continuous; and construction dams must be built every 20 ft. or 25 ft. to contain the grout laterally.

SCR Masonry Process

The Structural Clay Products Research Foundation at Geneva, Illinois has developed three aids for increasing the masonry wall area completed per day, as well as increasing the quality of the work, which should be given consideration. These aids consist of a marked line to show where each brick is to be laid; a scaffold easily adjustable in height and which, in addition to the platform on which the mason stands, incorporates a second platform at waist height for brick and mortar; and corner poles to support course guides which can be moved up course mark by course mark.

The foundation sells its own patented hardware for the poles which can be mounted on locally bought lumber. Adjustable scaffolds meeting the foundation's specifications are available from several manufacturers.

High lift booms for raising palleted brick and mortar hoppers can be used to advantage with this system on high rise buildings.

As with most new processes, savings cannot be expected until workmen become accustomed to taking advantage of its full utility. However, with union objections to the use of such auxiliary aids fast disappearing, any contractor expecting to remain competitive must utilize every possible means of increasing productivity.

Handling of Masonry By Palletization

For years builders have considered the use of palletization for handling masonry materials and many efforts have been made in this direction with indifferent success due to the lack of adequate handling equipment.

New systems have overcome this problem to the point where palletized masonry units, whether brick, block, or tile, can be transported from the manufacturing plant, through the job site, up the hoist and around the scaffold to the mason's station, eliminating all hand handling of units until the mason picks them up for laying. Two companies manufacturing this equipment are the West Brick Buggy Corp., Cleveland, Ohio and Prime-Mover Co., Muscatine, Iowa.

Time studies on over 300 jobs using the West system indicate that on jobs with ten or more masons the conventional ratio of 0.7 to 1.0 labor hour per mason hour can be reduced to 0.3 to 0.5 labor hours per mason hour — a saving of approximately 50 percent in labor time required for tending masons, or an overall saving on the total masonry labor cost of about 20 percent. These ratios include the labor time required to mix mortar, tend mortar, brick, tile, block, etc., and remove rubbish.

The success of these systems is mainly due to the equipment

used which consists of properly sized wooden pallets, a tractor with special design fork lift mechanism, special brick buggies and special mortar buggies.

For efficient use of this system and equipment, certain job conditions must be established from the start and maintained throughout the life of the job.

All materials must be purchased on the basis of pallet delivery or palletized as soon as they arrive on the job. Up to the present time, contractors have been furnishing the wood pallets, but dealers and manufacturers are showing an increasing preference for this type of delivery and in some cases furnish their own pallets. Contractor should specify the quantity of material to be placed on each pallet and the arrangement of same. Weight should not exceed 1,000 lbs. per pallet to stay within the capacity of scaffolding and buggies.

The effect on material prices for pallet delivery has been variable. Some suppliers have maintained their same prices, claiming the extra cost of labor and material for palletization is offset by savings in loading and unloading. Other suppliers have increased brick prices $1.00 to $2.00 per thousand. Actual cost of a 24" x 32" pallet, if palletization is done on the job site, is around $3.50 per pallet. One laborer can handle 6 to 7 pallets per hour.

Access roads to job should be laid out and maintained to facilitate operation of the fork lift tractor. Area surrounding the building should be backfilled, consolidated and graded before masonry work starts and kept reasonably clear thereafter.

Exterior scaffolding must be wide enough to permit maneuvering brick and mortar buggies. Where tubular steel scaffolding is used, this may be accomplished with standard scaffolding components, using a 5-ft. width tubular scaffold with the addition of a 30" bracket on the inside for the masons and a 20" bracket on the outside for the extra width required for buggies and storage of pallets. No special planking is required, but plank laps should all run in the same direction and a wood easement strip placed at each lap to partially eliminate that irregularity.

Where suspended scaffolding is used, extra width can be obtained by using 8-ft. wide Wheeling scaffold machines with the addition of 10-ft. pipe putlogs fastened directly under and through scaffold planking with U-bolts. This method moves the inside drum and cable 2'-0" out from the wall and creates a clear working space for the mason.

Scaffolding costs will be increased 5 to 15 percent, depending upon the type of scaffold used.

Standard Pallet 32" x 24".—A standard pallet size of 32" x 24" has been chosen because it accommodates all common sizes of brick, block and tile; loaded weight does not exceed safety regulations for scaffolding or light floor construction; accommodates just enough material to build 10 lineal feet of wall, 4 feet high, 4 inches thick, allowing proper spacing for stacking on the scaffold according to standard masonry practice; loaded weight can be handled by one man using hand powered equipment; pallet load can be split into two 16" x 24" pallet loads permitting passage through normal doorways, handling on occasional narrow scaffolds and maneuvering in confined spaces.

Pallets should be made to withstand hard use, preferably from a good grade of 1" lumber — 1 x 8 boards for the tops and 2" x 4" for skids. Pallets made on the job, using power saws and a production line set-up, should cost about $1.75 per half pallet (16" x 24") each, including material and labor.

One standard full size pallet is composed of two 16 x 24s strapped together with metal banding. When required, the metal banding can be removed, breaking the package into two halves of 16" x 24" for use where operating space is limited.

Fork Lift Tractors.—Manufacturers provide various capacities and sizes of rubber tired fork lifts having lifting heights from 18'-6" up to 30'-6" with capacities from 2,500 lbs. to 4,000 lbs. The 3,000 lbs. unit can unload and stockpile as many as 4,000 brick in 10 minutes, and can be used to handle concrete planks and roofing materials as well as masonry.

Fork lift tractor unloads pallets of material from delivery trucks and places them in stockpiles. From stockpiles, pallets are then transported to mason's stations at ground level or on the scaffold up to maximum reach of tractor; to construction hoist for work on scaffolds or floors beyond tractor reach; to building floors within tractor reach for partition work or exterior masonry performed from inside the scaffold.

The fork lift can handle as much palletized masonry material as 20 laborers, using conventional hand methods and wheelbarrows. It can also be equipped with other attachments to perform many other tasks on the job.

The fork lift also delivers mortar to the bricklayers from the mixing point by use of mortar buggies, which are mortar containers with a capacity of 7 cu. ft., equipped with wheels and casters so that they can be readily pushed on floors or scaffolds. The tractor handles these mortar containers to and from the mixer the same as packaged materials.

Brick Buggies.—Pallet loads are handled on the scaffold and

Skytrak Fork Lift Tractor Used in the West System of Material Handling

Stocking Mason's Station on Scaffold with Brick Using a West Brick Buggy

building floors with brick buggies. These come in a variety of sizes, either hand propelled or power driven, with capacities of 1,000 lbs. for half (16" x 24" pallets with 120 bricks) and 1,500 lbs. for full (24" x 32" pallets with 240 bricks) loads. Lifting forks can be had for 10", 7'-6" and 10'-0" lifts, the latter being able to feed double deck scaffolding. Buggies can be operated under average outdoor conditions as well as on up and down ramps.

Cost of lift trucks for 24" x 32" pallets is around $2,000.00. It can service 4 to 6 masons on a medium rise building instead of 1 laborer required to keep each mason supplied with brick. Two laborers, one on the ground and one delivering, should serve 5 masons.

The resulting savings at $5.00 per hour would amount to $120.00 per day and the lift plus the cost of pallets should be amortized in approximately 5 to 6 weeks under the best of conditions. Such handling also cuts down the time the hoist must be held for unloading by hand, which can be critical on larger jobs.

NAILON Facing Brick*

Nailon Facing Brick is a recently developed clay ceramic product for siding and facing work in lightweight construction and interior and exterior remodeling. It can also be adapted as an aggregate or surface for precast concrete panels. NAILON provides a true brick masonry surface, with only 25% of the weight, 9 lbs. per square foot, approximately 1" thick, and no foundation support required.

Nailon Brick can be applied to any nailable surface, such as plywood, wood sheathing, furring strips, various types of concrete masonry, etc.

Application is as follows: Work is laid out with special attention given to working out even courses in height. Units cannot be clipped horizontally without losing bottom lap or nailing flange. Slight adjusment of joint thickness is possible. Top line of first (bottom) course is located and marked in backing with chalk line or other method.

First course is nailed in place, two nails to the unit, with 4d annular grooved nails, or equal, preferably of aluminum.

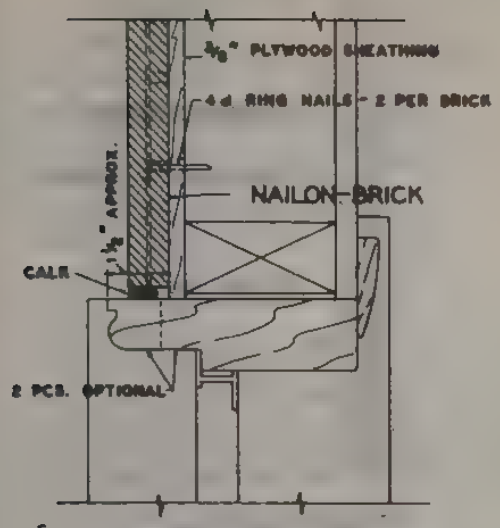
Joints may be pointed at any time after brick units are secured to backing. Mortar for pointing may be any workable mix, most contractors preferring a 1:1:6 lime-cement mortar or a 1:3 masonry cement mix with one fifth part lime added. During tuckpointing operation, brick surfaces should be kept as clean as possible. After joint or mortar has set properly, surfaces may be cleaned with a dilute solution of muriatic acid, if necessary.

Building trade jurisdiction on the application of NAILON Brick varies throughout the country.

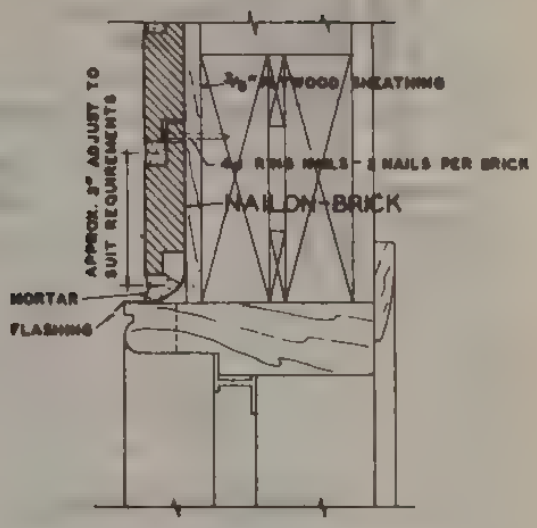
Nailon Brick stretcher units are available in two face sizes, 2½ x 7-⅝" and 2½ x 11½": Based on approximately ½" joints, one square foot of wall surface will require six of standard units and four of the larger Norman size units. Half brick and corner pieces are available for both sizes.

All prices given below are in dollars per thousand pieces, packed in cartons, f.o.b. factory, New Lexington, Ohio.

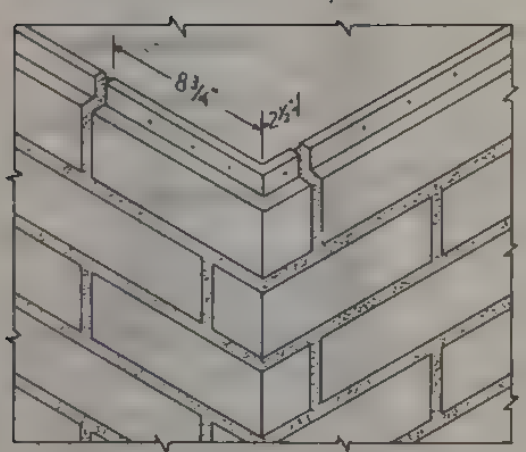
* Ludowici-Celadon Company, Chicago, Illinois



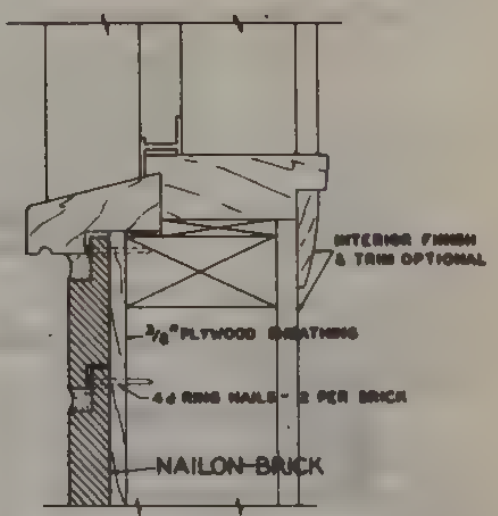
WINDOW JAMB
(DOOR JAMB SIMILAR)
NEW FRAME
CONSTRUCTION



WINDOW HEAD
(DOOR HEAD SIMILAR)
NEW FRAME
CONSTRUCTION

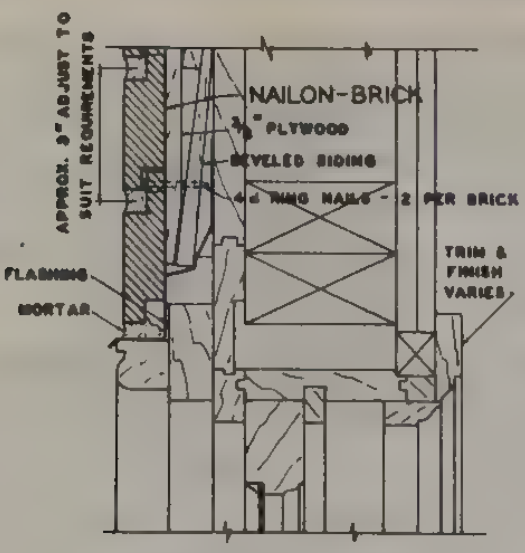


DETAIL OF CORNER
ALL CONSTRUCTION TYPES



WINDOW SILL
NEW FRAME
CONSTRUCTION

Construction Details Recommended for Use with NAILON Brick

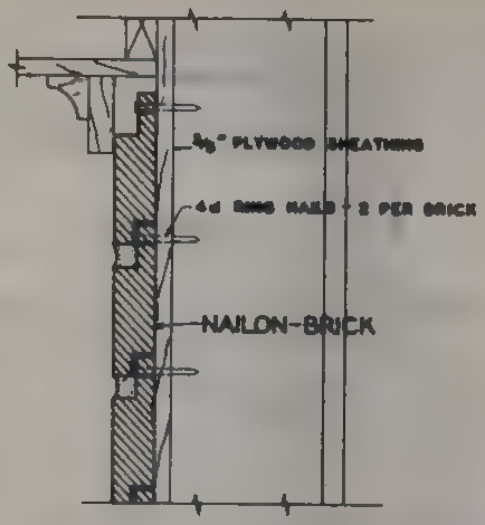


WINDOW HEAD

EXISTING FRAME CONSTRUCTION

BEVELED SIDING SHOWN

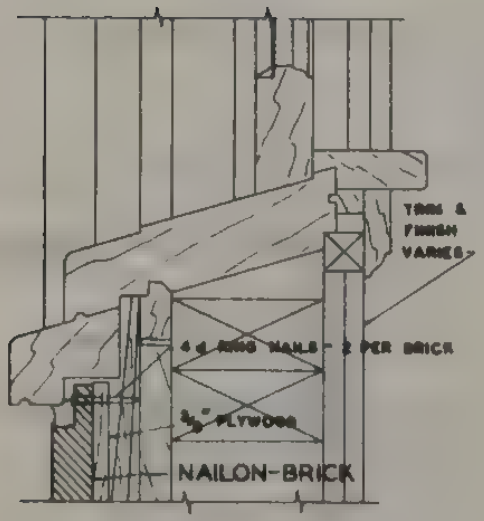
(FLUSH SIDING & STUCCO SIMILAR)



EAVE DETAIL

NEW FRAME CONSTRUCTION

(SIMILAR FOR OTHER TYPES)

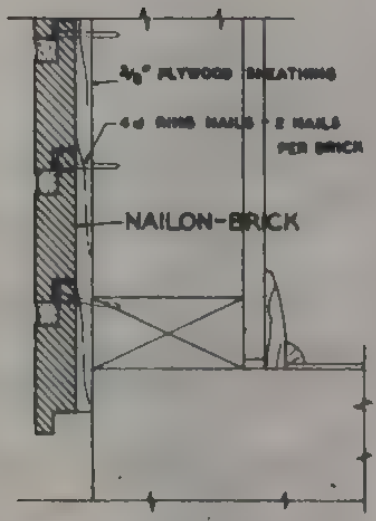


WINDOW SILL

EXISTING FRAME CONSTRUCTION

BEVELED SIDING SHOWN

(FLUSH SIDING & STUCCO SIMILAR)



SILL DETAIL

NEW FRAME CONSTRUCTION

(SIMILAR FOR OTHER TYPES)

Construction Details Recommended for Use with NAILON Brick

Prices of Nailon Brick — Standard Colors

Description	Smooth or Textured Red	Textured Golden Blend	Textured Gray
Stretcher 2½"x7-⅝"	$ 90.00	$ 99.00	$112.50
Half Brick 2½x3-⅝"	85.00	93.50	106.25
One Piece Corner 2½x6-⅝"	300.00	330.00	375.00
Stretcher 2½x11½"	110.00	121.00	137.50
Half Brick 2½x5½"	90.00	99.00	112.50
One Piece Corner 2½x8-¾"	300.00	330.00	375.00

On average small jobs, one mechanic working alone should lay out work and nail into place 650-750 standard brick or 550-650 Norman size brick per eight hour day. On larger jobs with two mechanics and a laborer the production should be 2½ to 3 times the above. Units may be cut to length with a guillotine-type cutter or scored with a masonry saw and broken.

One cubic foot of mortar will point 375 to 400 lineal feet of joint or 1½ cubic feet of mortar will point 100 sq. ft. of surface faced with smaller brick or 1-⅓ cubic feet mortar per 100 sq. ft. of larger brick.

On average jobs a tuckpointer working alone should mix mortar and point 425-475 square feet of small brick or 475-525 square feet of larger brick per eight hour day. It is not economical to provide a helper for the tuckpointers unless the job is large enough to require three or more masons for pointing work.

GLASS BUILDING BLOCKS

Glass blocks are hollow, partially evacuated units of clear or colored glass. They have been engineered to serve several functions, all providing good thermal and sound insulating values.

Clear and other non-light directing units are available in 5¾", 8" and 12" square units, all 3⅞" thick. These units give high light transmission and are available in clear glass for visibility, wide fluted patterns, and wavy, translucent surfaces. These units are often used in partitions and do not screen out sunlight.

Light directing units are engineered for use on sun exposures of rooms having finished ceilings to provide efficient reflection where such indirect daylighting is desired, such as in schools and offices. The basic size is 7¾" x 7¾" x 3⅞". These units can also be had with a white or green fibrous insert to reduce both glare and solar heat gain and are also available in 11¾" square size. The insert reduces the overall light transmission.

Light diffusing units diffuse light in all directions and give maximum light transmission. Size is 7¾" square. These units are also available with sun control inserts.

Color glass units have a ceramic coating fused to a single face of each block. They are used for decoration, often as accents with other blocks, and are available in 5¾" and 7¾" square units and 3¾" x 11¾" rectangles in eight colors.

Sculptured glass modules have various geometric shapes pressed into the glass to a depth of approximately 1½" on both sides of the unit. They are 11¾" square, and are available in clear glass and the lighter hues of the color glass units.

Grille wall units are patterned glass with a smooth exterior with an outline of grey colored ceramic frit fused at the edges leaving ovals, circles, dots and hour-glass designs exposed in the center. They are also available in solid grey frit. Sizes are 3¾" x 7¾" x 3⅞" and 7¾" square. The finish is scratch, abrasive and chemical resistant and will not fade from exposure. They make handsome and practical screen walls.

Mortar for Glass Blocks.—Materials used in making mortar for laying glass blocks shall be measured by volume. For this purpose 25 lbs. of quicklime or 40 lbs. of hydrated lime shall equal one cu. ft.

Lime shall be high-calcium or dolomitic hydrated lime. Dolomitic type lime must be pressure hydrated so that it does not contain more than 8 percent by weight of unhydrated oxides, in accordance with A.S.T.M. Specification C207-49 type S.

The mortar shall be composed of 1 part waterproof portland cement, 1 part lime and 4 parts well graded sand. It shall be mixed to a consistency as stiff and dry as possible and still retain good working characteristics. Prepared masonry mortars of high strength and low volume change may be substituted, when approved.

Setting accelerators or anti-freeze compounds are not to be used.

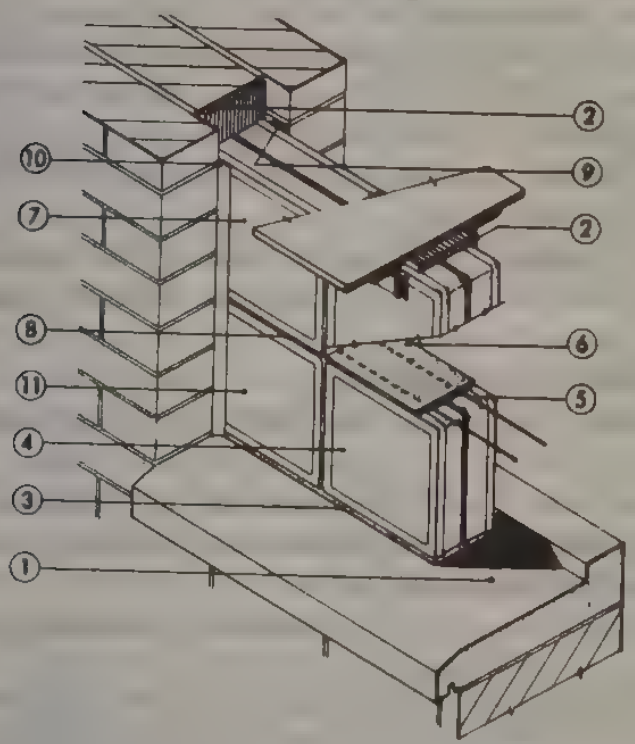
Expansion Joints.—Expansion joints must be provided at the head and jambs of each glass block panel. This expansion area shall contain expansion strips as designated by the details or specifications. Caulk head and jamb expansion joints and at intermediate reinforcing members with sponge plastic strip or rope and a good grade of non-hardening mastic so that all expansion joints are waterproof.

Panels in residential construction which are not over 5'-0" in width or 7' 0" in height, or 25 sq. ft. in area, may be mortared in solid without the use of expansion joints at the jambs. The expansion joint at the head must still be used to prevent loads from being carried by the panels. Reinforcing wall ties may be omitted in residential panels which do not exceed the above size limits.

Reinforcement.—Reinforcing wall ties shall consist of two No. 9 wires spaced 2″ apart to which are welded No. 14 gauge cross wires. Ties are to be 8′-0″ long and not more than .20″ thick at the weld. They shall be galvanized or treated with some other approved corrosion resisting coating. Ties are to run continuously with ends lapped 6″ and are to be installed in horizontal mortar joints approximately 24″ on centers.

Ties shall not be laid directly on the block, but shall be completely embedded in the center of the mortar joint.

Glass Building Units — Installation



1. Sill area to be covered by mortar shall first have a heavy coat of PC Asphalt Emulsion and allowed to dry.
2. Adhere PC Expansion Strips to jambs and head with PC Asphalt Emulsion. Expansion strip must extend to sill.
3. When emulsion on sill is dry, place full mortar bed joint—do not furrow.
4. Set lower course of block. All mortar joints must be full and not furrowed. Steel tools must not be used to tap blocks into position. Mortar shall not bridge expansion joints. Visible width mortar joint shall be ¼″ or as specified.
5. Install PC Panel Reinforcing in horizontal joints where required as follows:
   (a) Place lower half of mortar bed joint. Do not furrow.

(b) Press panel reinforcing into place.
(c) Cover panel reinforcing with upper half of mortar bed and trowel smooth. Do not furrow.
(d) Panel reinforcing must run from end to end of panels and where used continuously must lap 6 inches. Reinforcing must not bridge expansion joints.

6. Place full mortar bed for joints not requiring panel reinforcing. Do not furrow.
7. Follow above instructions for succeeding courses. The number of blocks in successive lifts shall be limited to prevent squeezing out of mortar or movement of blocks.
8. Strike joints smoothly while mortar is still plastic and before final set. At this time rake out all spaces requiring caulking to a depth equal to the width of the spaces. Remove surplus mortar from faces of glass blocks and wipe dry. Tool joints smooth and concave, before mortar sets so that exposed edges of blocks have sharp clean lines.
9. After final mortar set pack PC Oakum tightly between glass block panel and jamb and head construction. Leave space for caulking.
10. Caulk panels as indicated on details.
11. Final cleaning of glass block faces shall not be done until after final mortar set.

CLEANING—Surplus mortar shall be removed and block faces wiped dry as joints are tooled. Final cleaning shall be done by others after mortar has attained final set.

Courtesy Pittsburgh Corning

Labor Laying Glass Blocks.—In laying glass blocks, all mortar joints shall be completely filled with mortar. The joints shall not be less than $\frac{3}{16}$" thick or more than $\frac{3}{8}$" thick. Blocks shall not be hit with a metal tool but laid by the method known as "shoving," (working into place with the hands) thereby compressing the vertical joints.

It has been found when bricklayers' trowel handles are capped with a common type of rubber ferule, such as used on the bottom of crutches, they prevent damage to the glass.

After the mortar has passed its initial set, the exposed edges of the joints shall be tooled and thoroughly compressed with a round jointer. The finished surface of the joint shall be slightly concave, smooth and nonporous. The final cleaning shall not be done until after the mortar has reached its final set.

If blocks are in any way disturbed after laying, during the plumbing, tooling, or cleaning process, such blocks shall be removed and relaid.

Inasmuch as glass blocks do not absorb water, the mortar must be as stiff as possible and still be workable, otherwise the blocks will be inclined to slide and it will be difficult to lay up a straight wall and very few courses can be laid at a time as the weight of the glass blocks will squeeze the mortar out of the joints.

Basis for Estimating Labor Costs.—The labor costs on the following pages are based on one laborer to two masons, which includes time mixing and supplying mortar, glass blocks, etc. It does not include time building and removing scaffolding, placing expansion joint strips, packing joints with sponge plastic rope and caulking, nor does it include time required cleaning glass blocks after erection. These are given as separate items.

Panels containing more than 144 sq. ft. and not more than 25′-0″ in length or 20′-0″ in height should be braced by and anchored to structural stiffeners, so a fair average for all classes of work would be panels 10′-0″x10′-0″ in size, containing 100 sq. ft. Panels of this size have been used as a fair example for determining average costs.

Expansion joint strips ⅜″ thick, 4½″ wide and 25″ long are used at the heads, jambs and mullions of all openings. These strips are secured in place by an adhesive such as asphalt emulsion, and are butted together end to end to form a continuous cushion around the edges of the panels.

After the panels have been laid and the mortar has set, sponge plastic rope should be packed tightly between the side of the block and the sides of the "chase." Sponge plastic rope should be kept back ⅜″ from the finished surface. The recess thus formed should then be caulked with a non-hardening waterproof caulking material to a depth of not less than ⅜″.

In a 10′-0″x10′-0″ opening, caulked on both sides of the blocks, there will be 40 lin. ft. of caulking on the inside of the wall and 30 lin. ft. of caulking on outside of the wall or 70 lin. ft. for each opening. A man should pack rope into joints and caulk 30 to 40 lin. ft. (on one side) an hour.

To clean both sides of 100 sq. ft. of smooth face glass block wall will require 2 to 2½ hrs. labor time.

To clean both sides of 100 sq. ft. of ribbed face glass block (light directional type) will require 3 to 3½ hrs. labor time.

Erecting and removing scaffolding on the average job will require 1½ to 2 hrs. labor time per 100 sq. ft. of glass area.

Glass blocks must be carefully handled in unloading and handling on the job, as they require the same care as fine enameled brick.

Estimating Data on Laying Glass Blocks Using ¼-Inch Mortar Joints

Cost per 100 Sq. Ft. of Wall	Size of Glass Blocks in Inches		
	5¾x5¾x3⅞	7¾x7¾x3⅞	11¾x11¾x3⅞
Number of Blocks per Sq. Ft. of Wall*	4.00	2.25	1.00
Number of Blocks per 100 Sq. Ft. of Wall*	400	225	100
Cu. Ft. of Mortar Required**	5	3.6	2.33
Mason Hours	21 to 23	14 to 16	10 to 12
Labor Hours	10½ to 11½	7 to 8	5 to 6
Labor on Scaffolding, Hours	2	2	2
Mason Ramming Oakum and Caulking, Hours	1½	1½	1½
Mason Cleaning Blocks, Hours	2½	2½	2½
Expansion Strips, ⅜"x4⅛", Lin. Ft.	30	30	30
Wall Ties, Lin. Ft.	44	44	44
Sponge Plastic Rope Joints, Lin. Ft.	60	60	60
Caulking Joints, Lin. Ft.	70	70	70
Asphalt Emulsion, 40'-0"x4½"	½ pt.	½ pt.	½ pt.
Cost per 1,000 Glass Blocks (Based on 10x10 Panels)			
Cu. Ft. of Mortar Required**	12.5	16	23.3
Mason Hours	53 to 57	62 to 71	100 to 120
Labor Hours	27 to 29	31 to 36	50 to 60
Labor on Scaffolding, Hours	5	9	20
Mason Ramming Oakum and Caulking, Hours	3¾	6¾	15
Mason Cleaning Blocks, Hours	6¼	11	25
Expansion Strips, ⅜"x4⅛", Lin. Ft.	75	135	300
Wall Ties—Reinforcement, Lin. Ft.	110	200	440
Sponge Plastic Rope Joints, Lin. Ft.	150	266	600
Caulking Joints, Lin. Ft.	175	310	700
Asphalt Emulsion, 3½" Wide	1¼ pt.	2¼ pt.	2½ qts.
Number pcs. laid per 8-hr. day	140 to 150	115 to 125	70 to 80

*Does not include allowance for breakage. **Includes 10 percent for waste.

Cost of Mortar for Laying Glass Building Blocks

	Rate	Total	Rate	Total
25 lbs. quicklime.....	$.....	$.....	$0.87	$ .87
1 bag w'p'f portland cement	.....	.....	1.80	1.80
4 cu. ft. sand.....	.....	.....	.15	.60
Cost 4 cu. ft. mortar....		$.....		$3.27
Cost per cu. ft.....		.....		.82

Cost of Glass Blocks.—The cost of glass blocks varies with the kind, size and quantity required. Always obtain delivered prices on blocks, expansion strips and wall ties for each job figured.

Approximate Prices of Standard Glass Blocks Per Unit

Size Blocks	Up to 1,000 Sq. Ft.	From 1,000 Sq. Ft.	Carloads, Over 3,000 Sq. Ft.
5¾"x5¾"x3⅞"	$0.75	$0.65	$0.55
7¾"x7¾"x3⅞"	1.20	1.00	.80
11¾"x11¾"x3⅞"	3.00	2.80	2.60

Special block runs considerably more and should be checked locally for both price and availability. Block with color fired on one side will cost around $1.50 for 5¾" square units and $2.00 for 7¾". Screen wall block units of glass and fired-on frit will run around $3.00 for 7¾" squares; $1.85 for 3¾ x 7¾ rectangles. Sculptured block will run $7.00 to $8.00 per 11¾" square unit. The estimator figuring decorative work should study the design carefully, as often, two or more units are combined, or special color patterns are specified, all of which will increase labor costs.

Often, ventilator blocks will be shown built into glass block panels. These are specially formed aluminum units and will run approximately as follows:

Single units for 6" block.....$11.50
Double units for 6" block.....$15.00
Single units for 8" block.....$12.50
Double units for 8" block.....$18.50
Single units for 12" block.....$19.00

Prices on Accessories for Installing Glass Blocks

Fiberglass Expansion Joint Strips, ⅜"x4⅛"x25" ....Lin. Ft. $0.10
Wall Ties—Galvanized Wire Mesh, 8'-0" long .....Lin. Ft. .05
Wall Anchors—Perforated Galv. Steel, 1¾"x2'-0" ....Lin. Ft. .13
Asphalt Emulsion—to waterproof jambs and sill. 56 cts. qt., $1.32 per gal.; 5-gal. cans, $4.30.
Caulking Compound, per gal. $3.75
Oakum, per lb. 0.40

Cost of 100 Sq. Ft. of Wall Using $5\frac{3}{4}$x$5\frac{3}{4}$x$3\frac{7}{8}$-inch Glass Blocks

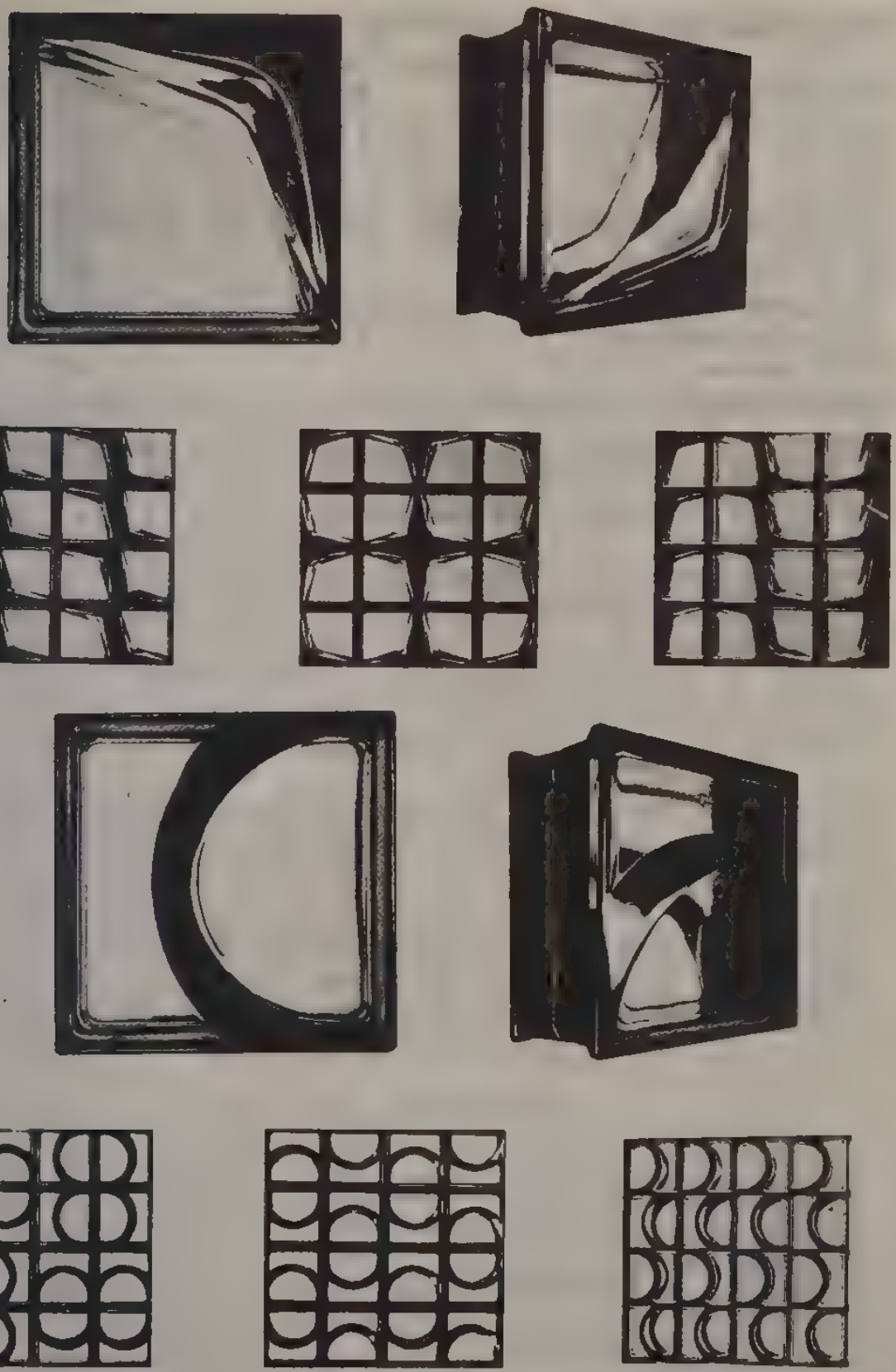
	Hours	Rate	Total	Rate	Total
410 glass blocks*		$.....	$.....	$0.75	$307.50**
5 cu. ft. mortar		.....	.....	0.82	4.10
Mason	22.0	.....	.....	7.10	156.20
Helper	11.0	.....	.....	5.00	55.00
Labor on scaffolding	2.0	.....	.....	5.00	10.00
30 lin. ft. expansion strips		.....	.....	.10	3.00
½-pt. asphalt emulsion		.....	.....	.56	.14
44 lin. ft. wall ties		.....	.....	.05	2.20
2 lbs. sponge rope for joints		.....	.....	.26	.52
⅜-gal. caulking compound		.....	.....	3.50	1.31
Mason caulking joints	1.5	.....	.....	7.10	10.65
Mason cleaning blocks	2.5	.....	.....	7.10	17.75†
Cost per 100 sq. ft. wall	39.0		$.....		$568.37
Cost per sq. ft.			.....		5.68

*Includes allowance for waste and breakage.
**Cost drops at 1000 and 3000 sq. ft.
†For cleaning ribbed face blocks, add 50 percent to cleaning labor.

Cost of 100 Sq. Ft. of Wall Using $7\frac{3}{4}$x$7\frac{3}{4}$x$3\frac{7}{8}$-inch Glass Blocks

	Hours	Rate	Total	Rate	Total
230 glass blocks*		$.....	$.....	$1.20	$276.00
3.6 cu. ft. mortar		.....	.....	.82	2.95
Mason	15.0	.....	.....	7.10	106.50
Helper	7.5	.....	.....	5.00	37.50
Labor on scaffolding	2.0	.....	.....	5.00	10.00
30 lin. ft. expansion strips		.....	.....	.10	3.00
½-pt. asphalt emulsion		.....	.....	.56	.14
44 lin. ft. wall ties		.....	.....	.05	2.20
2 lbs. oakum for joints		.....	.....	.26	.52
⅜-gal. caulking compound		.....	.....	3.50	1.31
Mason caulking joints	1.5	.....	.....	7.10	10.65
Mason cleaning blocks	2.5	.....	.....	7.10	17.75†
Cost per 100 sq. ft. wall	28.5		$.....		$468.52
Cost per sq. ft.			.....		4.69

*Cost drops at 1000 and 3000 sq. ft.
†For cleaning ribbed face blocks, add 50 percent to cleaning labor.



TWO STYLES OF DECORATIVE GLASS BLOCK

Two styles of 8″x8″x4″ block showing three possible patterns formed by each style when arranged into panels of sixteen units.

Cost of 100 Sq. Ft. of Wall Using 11¾x11¾x3⅞-inch Glass Block

	Hours	Rate	Total	Rate	Total
102 glass blocks*		$.....	$.....	$3.00	$306.00
2.33 cu. ft. mortar		.....	.....	.82	1.91
Mason	11.0	.....	.....	7.10	78.10
Helper	5.5	.....	.....	5.00	27.50
Labor on scaffolding	2.0	.....	.....	5.00	10.00
30 lin. ft. expansion strips		.....	.....	.10	3.00
½-pt. asphalt emulsion		.....	.....	.56	.14
44 lin. ft. wall ties		.....	.....	.05	2.20
2 lbs. oakum for joints		.....	.....	.26	.52
⅜-gal. caulking compound		.....	.....	3.50	1.31
Mason caulking joints	1.5	.....	.....	7.10	10.65
Mason cleaning blocks	2.5	.....	.....	7.10	17.75†
Cost per 100 sq. ft. wall	22.5		$.....		$459.08
Cost per sq. ft.			.....		$4.59

*Includes allowance for breakage.
†For cleaning ribbed face blocks, add 50 percent to cleaning labor.

CHAPTER XIII

CLAY AND GYPSUM TILE WALL UNITS

Tile units are furnished in many styles, sizes and shapes, for both interior and exterior, and load and non-load bearing conditions.

Much tile used today has a finished surface, others are scored for plaster and stucco finish applied by other trades. Tile is often used as backup on exterior walls, as it provides better insulation than brick (a "U" factor of .26 as against .35 for face brick walls backed 8" of tile and common brick respectively), and provides a drier surface for plastering direct.

Clay and gypsum tile are used as non-bearing partitions and serve as a base for plastering direct. Clay tile partitions are preferable to gypsum units in damp locations such as around toilet rooms, whether plastered or used with finished surfaces, but gypsum units are more widely used today than tile for office subdivision.

Tile was long used as fireproofing for beams and columns, but is largely replaced today by plaster, although gypsum tile is often used to enclose columns.

Tile arch and book tile roof construction was once quite common but is seldom encountered today except in remodeling older structures. Tile used with concrete for slabs is discussed in Chapter VIII. Tile for silos is included in Chapter X. Gypsum slabs, both poured and precast, are also included in Chapter X.

LOAD BEARING TILE

Load bearing tile are used to carry part of the structural load of the building and are used for both interior and exterior walls. Some units have finished surfaces, some are scored for plaster, or other applied finishes.

The American Society for Testing and Materials (A.S.T.M.) has set up three specifications covering load bearing tile. Specification C-34-62 covers structural clay load-bearing wall tile in general and sets two grades: LBX for exposed locations; LB for units not exposed to frost or where protected with at least 3" of other masonry facing.

Tile are manufactured as end construction tile, to be placed in

walls with axes of cells vertical and as side construction tile, to be placed with axes of cells horizontal. Average compressive strength of end construction tile, Grade LBX, is 1,400 p.s.i., and for Grade LB, 1,000 p.s.i. Average compressive strength for side construction tile is 700 p.s.i., for both grades, based on gross area.

A.S.T.M. Specification C-212 covers structural facing tile designed for either interior or exterior exposure, including salt glazed and unglazed units. The two grades are FTX for smoothest faces, low absorption and high degree of mechanical perfection, and FTS, which provides moderate absorption and mechanical perfection.

The compressive strengths given above for LBX grade tile apply here except that a special duty tile is available with 2,500 p.s.i. and 1,200 p.s.i. average compressive strength for end and side construction types respectively. The Facing Tile Institute, an affiliate of the Structural Clay Products Institute, specifications list considerably higher strengths of 3,000 and 2,000 p.s.i. respectively, for "select" tiles.

A.S.T.M. Specifications C-126-62 covers structural tile with ceramic glazed surfaces. Two grades are given: "S" (select) for use with comparatively narrow joints, and "G" (Facing Tile Institute lists this as "SS") for ground edge tile. Grade S is available in all standard sizes except 7¾"x15¾" and "G" (or "SS") is available in 7¾"x15¾" units. These units also carry the designation, Types I and II, which indicates single or double finished faces. The Facing Tile Institute also lists a "B" quality ceramic glaze structural tile. These are not produced to meet a specification, but are units that may be available at the yard which fail to meet one or more of the specifications for "S" grade tile. The estimator should be aware, however, that even when "B" quality is acceptable on a job, it may be impossible to get all the special shapes required to complete the job in anything other than select quality.

INTERIOR STRUCTURAL CLAY FACING TILE

Facing tile discussed below includes those units at least one of whose faces, ceramic glazed, salt glazed or unglazed, are designed to be left exposed either as a partition, as backup to another type of facing, or as the inner wythe of a cavity wall.

These units are manufactured in accordance with sizes and specifications adopted by the Facing Tile Institute. The four sizes adopted are modular.

Facing tile are available in such a wide variety of colors and finishes as to be adaptable to most any design requirement, and the estimator must be knowledgeable about the product and grade and the desired end result in preparing his proposal.

While most facing tile is furnished in 4" thicknesses, the estimator at some distance from his tile supply should always check the cost of using 2" soaps in combination with a locally produced backing material against the cost of the full width tile, particularly if the wall carries no superimposed loads. Often, structural tile is used where its load bearing capacity is never utilized.

Mortar design mixes for tile follow those listed in the previous chapter for brick, except interior non-load-bearing partitions may utilize a low strength type "0" mortar which calls for .111 cu. ft. of cement and .222 cu. ft. of lime for each cubic foot of sand. Note, however, that in much tile work white portland cement and white sand may be called for. Most facing tile is figured for ¼" joints which limits sand to that passing a No. 16 sieve.

In the figures given below, mortar is figured as two separated 1" wide joints except for the bed joints of horizontal celled units which are figured as full.

Where walls are built up of two units in thickness, metal ties should be figured 16" vertically and 36" horizontally, which will work out about 25 per 100 sq. ft. in all. Also if a solid filled collar joint is desired add 2.6 cu. ft. of mortar per 100 sq. ft. of wall.

Material Requirements for Facing Tile

8W Series.

Size: 8"x16"x2" or 4" thick
(7¾"x15¾" actual face size)
Tile per sq. ft. wall - 1.125
Mortar in cu. ft.:
For vertical cell tile:
.77 per 100 sq. ft.
6.87 per 1000 units
For horizontal cell tile:
1.23 per 100 sq. ft.
10.92 per 1,000 units
Cost: 4" thick - $950.00 per M, or $1.06 per sq. ft., glazed 1 side
4" thick - $1260.00 per M, or $1.42 per sq. ft., glazed 2 sides

6T Series.

Size: 5⅓"x12"x2", 4", 6", and 8" thick.
(5 1/16"x11¾" actual face size)
Tile per sq. ft. wall - 2.250
Mortar in cu. ft.:
For vertical cell tile:
1.11 per 100 sq. ft.
4.94 per 1,000 units

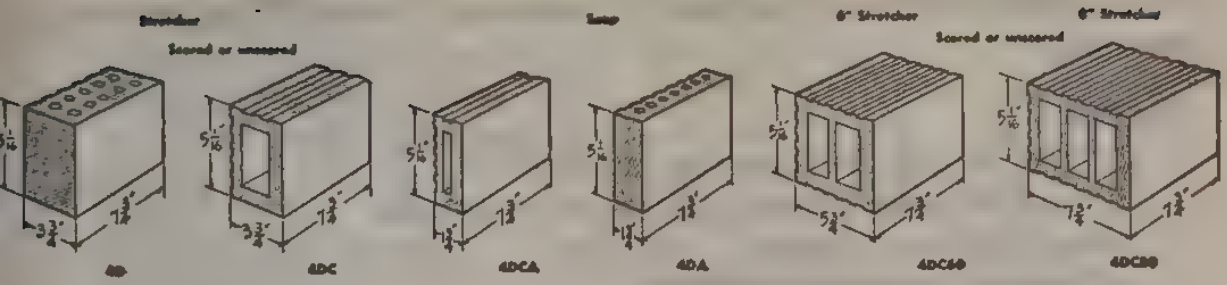
For horizontal cell tile:
1.80 per 100 sq. ft. for 4" wall
7.98 per 1,000 units for 4" wall
2.58 per 100 sq. ft. for 6" wall
11.45 per 1,000 units for 6" wall
3.36 per 100 sq. ft. for 8" wall
14.93 per 1,000 units for 8" wall
Cost: 2" thick - $240.00 per M, or $0.54 per sq. ft., glazed 1 sid
4" thick - $390.00 per M, or $0.97 per sq. ft., glazed 1 sid
4" thick - $490.00 per M, or $1.10 per sq. ft., glazed 2 side

4D Series.
Size: 5⅓"x8"x2", 4", 6", and 8" thick.
(5 1/16"x7¾" actual face size)
Tile per sq. ft. wall - 3.375
Mortar in cu. ft.:
For vertical cell tile:
1.28 per 100 sq. ft.
3.79 per 1,000 units
For horizontal cell tile:
1.96 per 100 sq. ft. for 4" wall
5.81 per 1,000 units for 4" wall
2.74 per 100 sq. ft. for 6" wall
8.13 per 1,000 units for 6" wall
Cost: 2" thick - $200.00 per M, or $0.675 per sq. ft., glazed 1 side
4" thick - $270.00 per M, or $0.93 per sq. ft., glazed 1 side
4" thick - $360.00 per M, or $1.22 per sq. ft., glazed 2 sides

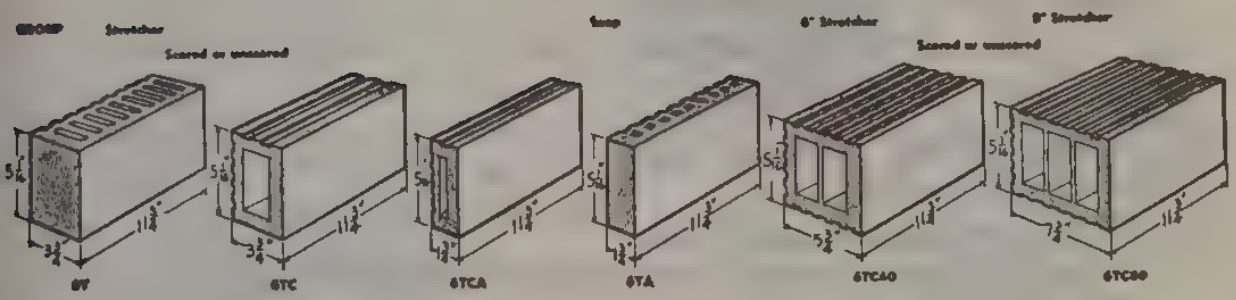
4S Series (brick size tile).
Size: 2⅝"x8"x2" and 4" thick
(2⅝"x7¾" actual face size)
Tile per sq. ft. wall - 6.75
Mortar in cu. ft.:
For ¼" joints: 3.81 per 100 sq. ft. wall
5.65 per 1,000 units
For ⅜" joints: 5.47 per 100 sq. ft. wall
8.10 per 1,000 units
For ½" joints: 6.95 per 100 sq. ft. wall
10.30 per 1,000 units

Special Shapes.—In addition to stretcher, or field units, these series also include many special shapes. These are given as belonging to groups; the higher the number, the more expensive the unit.

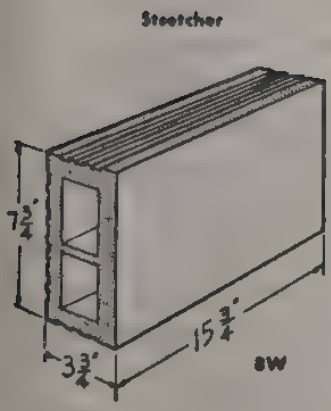
In general, the various groups include the following, although

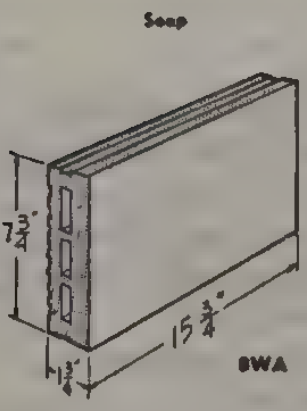


4D Series Structural Facing Tile, 5-⅓"x8" Face

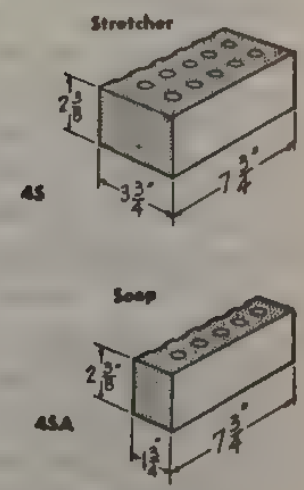


6T Series Structural Facing Tile, 5-⅓"x12" Face





8W Series Structural Facing Tile, 8"x16" Face



4S Series 2-2/3"x8" Face

not all units will be available in all tile. Series 4S is especiall limited.

Group I:

4″ bed return, bullnose or square
2″ and 4″ soap return, bullnose or square
coved internal corner
octagonal external corner
octagonal interior corner
cost: 8W—$1050.00 per M
6T —$ 500.00 per M

Group II:

2″ and 4″ bed, bullnose cap
2″ bed, cove base
cost: 8W—$1150.00 per M
6T —$ 600.00 per M

Group III:

6″ and 8″ bed, bullnose cap
4″ bed, cove base
2″ bed, round top cove base
4″ and 8″ bed, full and half ends glazed both sides
4″ bed, bullnose cap, glazed both sides
4″ bed, sloped sill

Standard radial external or internal field units:
2″ and 4″ bed, 6⅜″ high, bullnose cap unit
2″ and 4″ bed, 7¾″ high, bullnose cap unit
cost: 8W—$1450.00 per M
6T —$ 800.00 per M

Group IV:

4″ bed, miter unit
4″ bed, miter unit with top return
4″ bed, miter unit with finished end
2″ and 4″ bed, bullnose return
4″ bed, bullnose return with starter
2″ and 4″ bed, cove base with return
4″ bed, round top cove base
6″ bed, bullnose glazed both sides
6″ and 8″ bed, sloped sill
4″ bed, bullnose starter
2″ bed, bullnose reveal
2″ bed, bullnose coved internal corner
2″ bed, bullnose octagonal internal and external corners

4" bed, 6⅜" high slope sill
4" bed, 7¾" high slope sill
cost: 8W—$1900.00 per M
6T —$1100.00 per M

Group V:
4" bed, bullnose with 4" return
4" bed, miter 7¾" high with face return
4" bed, round top cove base with 4" return
2" bed, round top cove base with 4" return
2" bed, bullnose radial
2" bed, bullnose cove base radial
4" bed, bullnose internal corner with 4" reveal
6" bed, 6⅜" high slope sill
2" bed, round top cove base with square corner
2" bed, round top cove base with coved interior corner
2" bed, round top cove base with octagonal exterior corner
2" bed, round top cove base with octagonal internal corner
4" bed, field radial starter
cost: 8W—$2400.00 per M
6T —$1600.00 per M

Group VI:
4" bed, bullnose full end, or half end glazed both sides
8" bed, bullnose half end, glazed both sides

Group VII:
4" bed, bullnose radial starter
4" bed, cove base radial starter

SCR "Acoustile"*

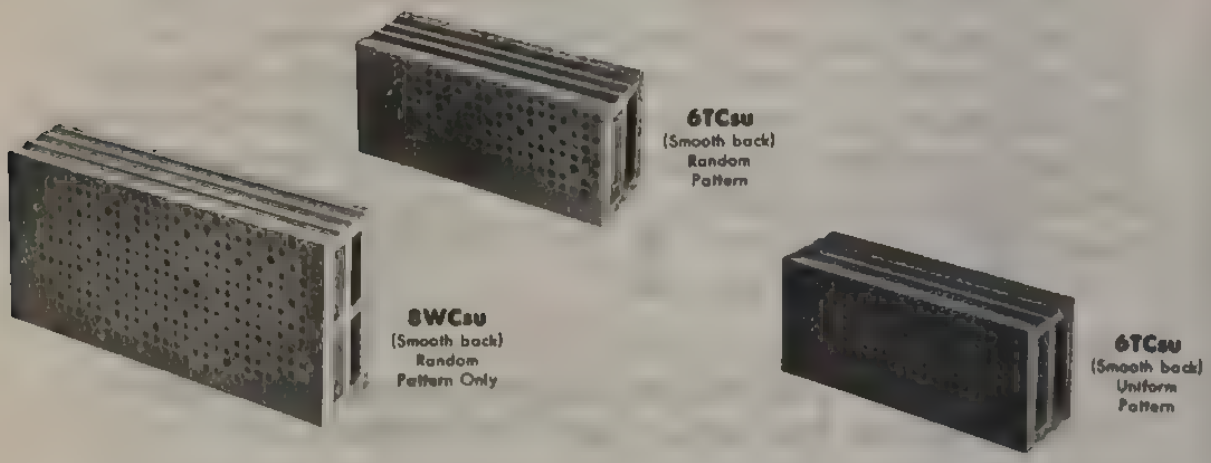
In addition to standard facing tile, a glazed facing tile unit with a perforated face shell and the adjacent cell filled at the factory with Fiberglas has been developed by the Structural Clay Products Research Foundation to combine high sound absorption with the advantages of ceramic finish and a structural wall material. These units are produced by several manufacturers with a wide selection of colors, types of slots and in both 6T and 8W series, of facing tile. Thickness is 4" and, upon special order, both sides can be perforated.

Not only does this tile allow acoustical control in areas where ceramic veneer is desired, but it opens possibilities of adding acoustical control to other wall areas where less durable materials would be damaged by wear and tear or would lose much of their value because of the need of constant repainting.

* Reg. TM, US Pat. Off., Patent No. 3,001,602

Acoustile walls provide mass so as to reduce sound transmission as well as provide sound absorption, and the combination of Fiberglas and open cells provide a barrier for heat transmission. These units are available as field or stretcher units only, and are used in connection with special shapes of standard series ceramic facing block. These are horizontal celled units and requirements given above will apply here also. Cost is $1.75 per unit for 6T series.

SCR "Acoustile" *



* Reg. TM, US Pat. Off., Patent No. 3,001,602

Sculptured Ceramic Tile

Certain manufacturers produce units with cast in designs and profiles. These are usually on special order, but may have some application in lobbies or meeting rooms. Costs run around $1.75 per unit in the 6T series.

Estimating Facing Tile Quantities

The most widely used estimating procedure is the wall area method, as follows:

1. Compute gross wall area (height times length). Where coved base and/or bullnosed caps are specified, do not figure these in overall height.
2. Determine net area of wall; deduct wall openings. These are computed by using the actual width multiplied by the actual

height plus the height of special sill and lintel units. Where openings overlap base or cap units, do not include this in the opening height as it was not included in the gross area. Also deduct for other special shapes by multiplying their height by the following factors:

For exterior bullnose or square corners—1.167 per ft. of height.

For interior coved corners—.833 per ft. of height.

For bullnose or square jambs—.75 per ft. of height.

3. Determine number of stretchers required by multiplying net area by number of stretchers required per square foot.

   8W: 1.12
   6T: 2.25
   4D: 3.37

4. Compute number of standard fittings such as corners and jambs by the number of courses. Cove bases and caps, which should now be included as well as sills and lintels, are computed by the linear foot. Miters, cove base corners, etc., should be taken off individually.
5. Summarize quantities and separate fittings in particular group.
6. Multiply by the unit cost figures.
7. Add 2% (or more, depending on job conditions) to cover breakage. Example:

Step 1

Wall length = 29′-0″
Wall height, exclusive of the base course = 8′-0″
Gross area = (8.00) (29) = 232 sq. ft.

Step 2

Deductions:

Window area (4) (4.89)	= 19.56 sq. ft.
Door area (2) (6.67)	= 13.33 sq. ft.
Exterior corner (1.167) (8.00)	= 9.33 sq. ft.
Interior coved corner (0.833) (8.00)	= 6.66 sq. ft.
Jambs (4+4+6.22+6.22) (0.75)	= 15.33 sq. ft.
Total	= 64.21 sq. ft.
Net wall area = 232 minus 64.21	= 167.79 sq. ft.

Step 3

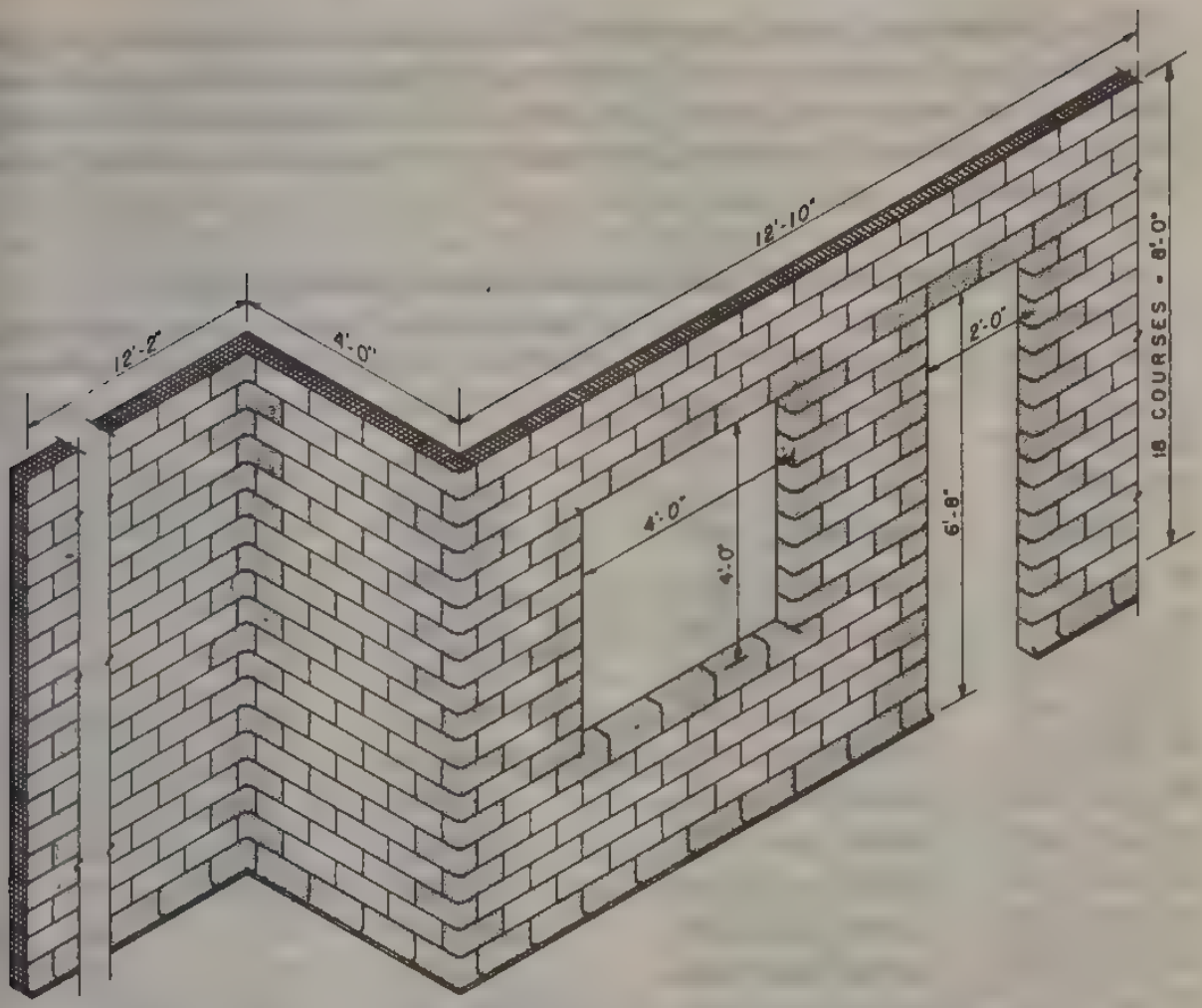
Number of 6T stretchers required (167.79) (2.25) = 378

Step 4	Group I	II	III	IV	V
Exterior bullnose corner					
18 courses of 5T4	18				
Interior coved corner					
18 courses of 4T8	18				
Jambs					
24 courses of 6T4	24				
24 courses of 3T4	24				
Lintels					
5 lin. ft. of 6T20		5			
1 miter 6T30R (door)				1	
1 miter 6T30L (door)				1	
1 miter 8T31R (window)					1
1 miter 8T31L (window)					1
Sill					
3 lin. ft. of 6T20		3			
1 miter 8T31R					1
1 miter 8T31L					1
Cove base					
25 lin. ft. of 6T50			25		
1 outside corner 5T54L				1	
1 inside cove corner 4T58L				1	
1 bullnose jamb 6T504R				1	
1 bullnose jamb 6T504L				1	
Totals	84	8	25	6	4

Step 5—Summary

Group	Series	Quantity
Stretcher	6T	378
I	6T	84
II	6T	8
III	6T	25
IV	6T	6
V	6T	4

Add an arbitrary percentage to the quantities taken off for breakage, to vary between 2 and 5% according to job conditions as well as distance of job from the plant. Chippage can frequently be used for special short lengths or other cuts.



Example of Wall Area Method for Determining Facing Tile Quantities

A short cut method, devised by Stark Ceramics, is based on the following formula:

(Length × height minus actual openings) × (cost per sq. ft.) + (lineal feet × lineal foot cost factor) = (total material cost).

In using this method, actual total heights are used to figure cross areas and openings are figured using actual height and width with no allowances for sills, lintels, caps or bases. Lineal footage includes all special shapes: cove bases, internal coved corners, jambs, sills, lintels, caps, etc. The lineal foot cost factor is an average additional cost to cover these items. It is determined by taking an average of the group costs and deducting the stretcher unit cost already included in the net area figure. For 6T series, this will be 53¢; for 8W series, 64¢.

Labor Laying Glazed Structural Facing Tile.—To insure the most economical construction, as well as the most attractive appearance in the finished work, all cutting of tile on the job should be done with a power saw using a carborundum blade.

The following labor quantities are based on the average job requiring not more than 20 percent of special shapes, such as bullnose corners, cove base, cap, etc. If the percentage of special pieces vary from the above, increase or decrease labor time proportionately.

Labor Laying Glazed Structural Facing Tile

Nominal Size of Tile*	Class of Work	No. Pcs. Set per 8-Hr. Day	Labor Hrs. per 100 Pcs Mason	Labor
2"x5⅓"x 8"	Glazed one side.....	155-175	4.8	4.8
4"x5⅓"x 8"	Glazed one side.....	155-175	4.8	4.8
4"x5⅓"x 8"	Glazed two sides.....	125-155	5.7	5.7
6"x5⅓"x 8"	Glazed one side.....	155-175	4.8	4.8
6"x5⅓"x 8"	Glazed two sides.....	125-155	5.7	5.7
8"x5⅓"x 8"	Glazed one side.....	125-155	5.7	5.7
8"x5⅓"x 8"	Glazed two sides.....	105-120	7.0	7.0
2"x5⅓"x12"	Glazed one side.....	115-135	6.4	6.4
4"x5⅓"x12"	Glazed one side.....	115-135	6.4	6.4
4"x5⅓"x12"	Glazed two sides.....	90-110	8.0	8.0
6"x5⅓"x12"	Glazed one side.....	105-125	7.0	7.0
6"x5⅓"x12"	Glazed two sides.....	80-100	8.9	8.9
8"x5⅓"x12"	Glazed one side.....	85-100	8.7	8.7
8"x5⅓"x12"	Glazed two sides.....	65-85	10.6	10.6
2"x8 "x16"	Glazed one side.....	65-80	11.0	11.0
4"x8 "x16"	Glazed one side.....	55-65	13.3	13.3

Add for hoisting engineer if required.

*Nominal size includes thickness of standard mortar joint (¼" for glazed tile) in length, height and thickness.

Tile 1¾" thick is usually used for wall furring or partition wainscoting. Tile glazed one side is usually used for partitions that are glazed on one side and plastered on the other side. Tile glazed two sides are usually used for partition walls glazed on both sides of wall.

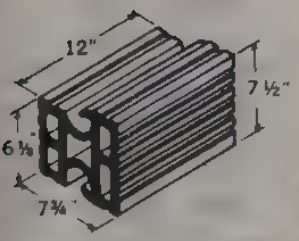
Backup Tile

Backup tile are sized for backing up brickwork, but are also used with stone and other facing. These units are available with nominal face sizes of 5⅓"x12", 8"x12", and 8"x16", in thickness of 4", 6", 8" and 12", and are usually furnished scored one side, smooth on the other. These units are often available, especially in larger sizes, in special designs with cast in handles for greater

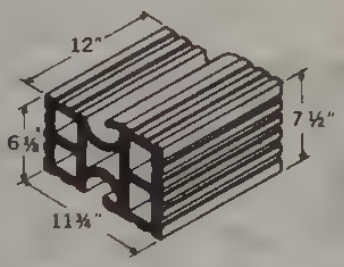
speed and ease in handling and non-continuous mortar joints to protect against moisture penetration. An example of this is the Speed-A-Backer tile, Kwiklay and Denison backup tile, patented units produced by many local manufacturers. These all come with special header and closure units. Generally, backup tile is sized to have ½" joints, which is the mortar amount given below, but certain units will be found to allow for less. Dimensional tolerances are wider in this type than in facing tile. The mortar figures below assume joints consist of two separated 1" wide joints and bed joints are two separated 2" wide joints.

Nominal 5"x12" tile:
$4\frac{7}{8}$"x$11\frac{1}{2}$"x$3\frac{1}{2}$", $5\frac{1}{2}$", $7\frac{1}{2}$" and $11\frac{1}{2}$" actual
Tile per sq. ft. wall—2.25
Mortar—per 100 sq. ft. wall—3.75 cu. ft.
—per 1,000 units—16.69 cu. ft.

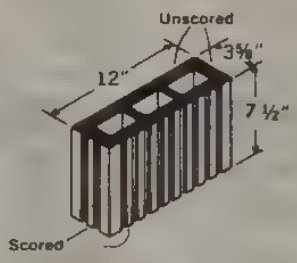
Nominal 8"x12" tile:
$7\frac{1}{2}$"x$11\frac{1}{2}$"x$3\frac{1}{2}$", $5\frac{1}{2}$", $7\frac{1}{2}$" and $11\frac{1}{2}$" actual
Tile per sq. ft. wall—1.5
Mortar—per 100 sq. ft. wall—2.73
—per 1,000 units—18.23



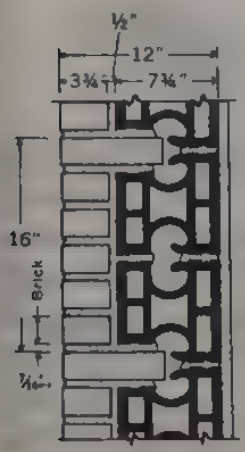
8" S.A.B. Stretcher



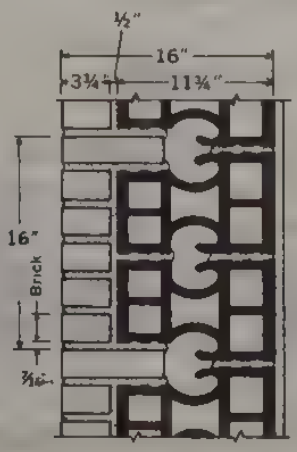
12" S.A.B. Stretcher



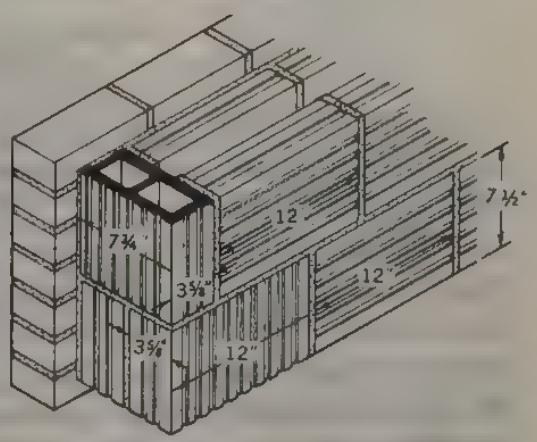
12" Full Closure



12" Wall Section



16" Wall Section



TYPICAL JAMB DETAIL—12" WALL

Speed-A-Backer Tile

Nominal 8"x16" tile:
7½"x15½"x3½", 5½", 7½" and 11½" actual
Tile per sq. ft. wall—1.125
Mortar—per 100 sq. ft. wall—3.43
—per 1,000 units—22.8

Approximate Prices of Kwiklay Loadbearing and Backup Tile

Tile Number	Actual Size of Tile	Wall Thickness	Price per 1,000 Pcs
45-BU	3½"x4⅞"x11½"	4"	$ 90.00
85-BU	7½"x4⅞"x11½"	8"	165.00
85-CBU	3½"x4⅞"x11½"	4"	125.00
88-BU	7½"x7½"x11½"	8"	255.00
88-CBU	3½"x7½"x11½"	4"	195.00

Above prices f.o.b. factory. Add freight and trucking.

Labor Laying Backup Tile.—The following quantities are based on the average job, having the usual number of openings, pilasters, etc.

Size Tile	No. Pcs. Laid per 8-Hr. Day	Labor Hrs. 100 Pcs. Mason	Labor	Engr.*	No. Sq. Ft. Laid per 8-Hr. Day	Labor Hrs. 100 Sq. Ft. Mason	Labor	Engr.*
3½"x4⅞"x11½"	330-370	2.25	2.25	0.3	150-170	5.0	5.0	0.6
7½"x4⅞"x11½"	250-290	3.00	3.00	0.3	115-130	6.5	6.5	0.7
7½"x7½"x11½"	155-185	4.70	4.70	0.5	110-132	6.6	6.6	0.7
3½"x7½"x11½"	200-225	3.80	3.80	0.3	135-150	5.7	5.7	0.6

*Add for hoisting engineer only if required.

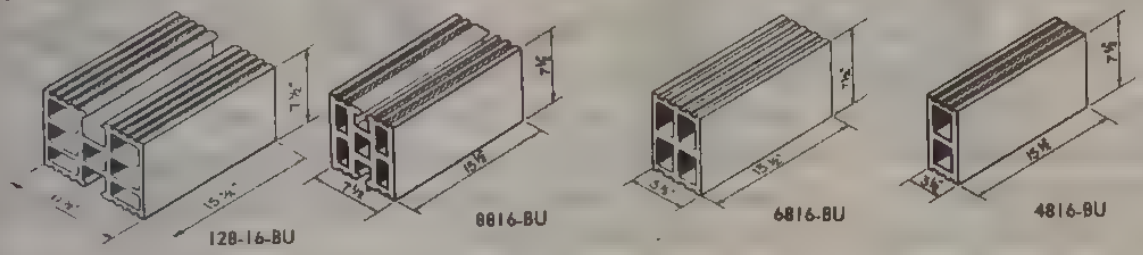
Unit Wall Tile

Some tile units are designed to be used for a complete single unit, load bearing, nominal 8" wall construction, with finished surfaces inside and out. These are usually manufactured under special patents and include such products as Uniwall, Dri-Speed wall and Tex Dri-wall, all manufactured by Glen-Gery Corporation, and certain units produced by local manufacturers under patents and known as Kwiklay. Some of these units may have one finished surface only and be used in combination with an inside backup.

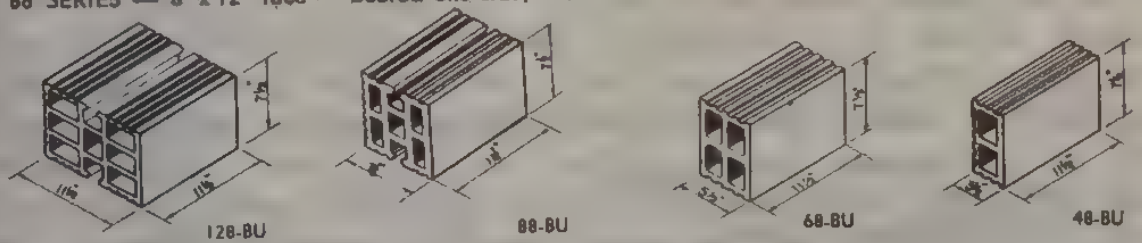
Faces are available in buff unglazed, either smooth or Ruggtex

DENISON BACK UP TILE

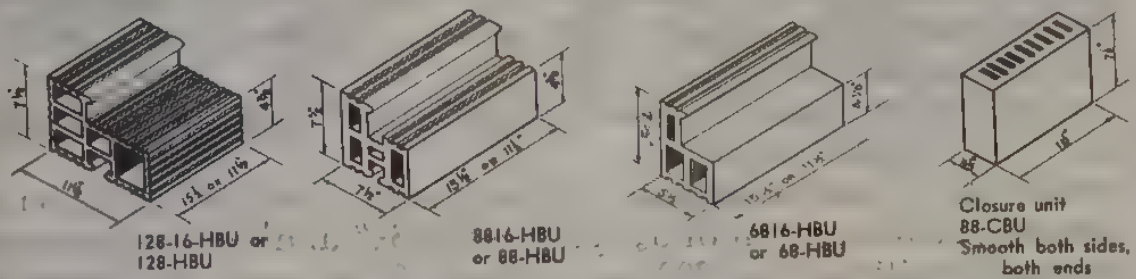
8816 SERIES — 8" x 16" face — Scored one side, smooth one side



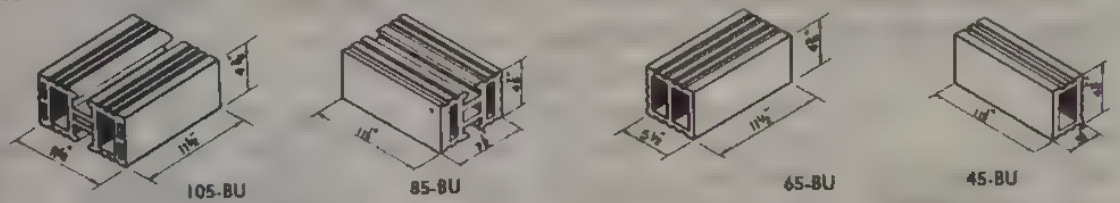
88 SERIES — 8" x 12" face — Scored one side, smooth one side



HEADER UNITS



85 SERIES — 5" x 12" face — Scored one side, smooth one side



ESTIMATING DATA

8816 Series — 1.1 units/sq. ft.
88 Series — 1.5 units/sq. ft.
85 Series — 2.25 units/sq. ft.

Units may be scored two sides or smooth two sides if desired.

DENISON STRUCTURAL CLAY TILE
MASON CITY BRICK AND TILE COMPANY, MASON CITY, IOWA

finish; salt glazed, red textured (to give the appearance of high quality face brick); and ceramic glaze. Certain units are offered with supplemental full and half jamb corners, and lintel and

pilaster units along with interior stretcher units to match the interior face of the unit tile.

Units are also available in 4" widths for use as exterior wythes in cavity wall construction.

A wall of this type is highly impervious to water, thoroughly fire-, termite and vermin proof, and cannot rot or decay. Textures offer a broad range including brick-like textures and colors suitable for homes and schools; glazed for situations where a sanitary finish is desired, and smooth faced units in natural range shades suitable for larger structures and areas.

The estimator must know exactly the quality of interior finish desired. While it is possible to obtain high grade finishes and workmanship both sides, such high quality is not always required, especially in larger warehouse and manufacturing buildings, and large economies can result where "select one face" units can be used. Often the lower wall may be constructed "select two faces" while "select one face" is used above. In general, though, the estimator must expect a variation of $\frac{1}{8}$" in thickness and, if this is not acceptable, he should plan to use a built-up wall with a separate interior facing.

Unit wall tile comes in two nominal face sizes: 4"x12", and $5\frac{1}{3}$"x12", in 4" and 8" widths.

4"x12" units, which include Uniwall and Tex Dri-wall, have an actual face dimension of $3\frac{5}{8}$"x$11\frac{5}{8}$" with $3\frac{5}{8}$" and $7\frac{5}{8}$" thicknesses. These units will lay up 300 per 100 sq. ft. of wall and require 7.5 cu. ft. of mortar for 4" walls; 9.75 cu. ft. for 8" walls.

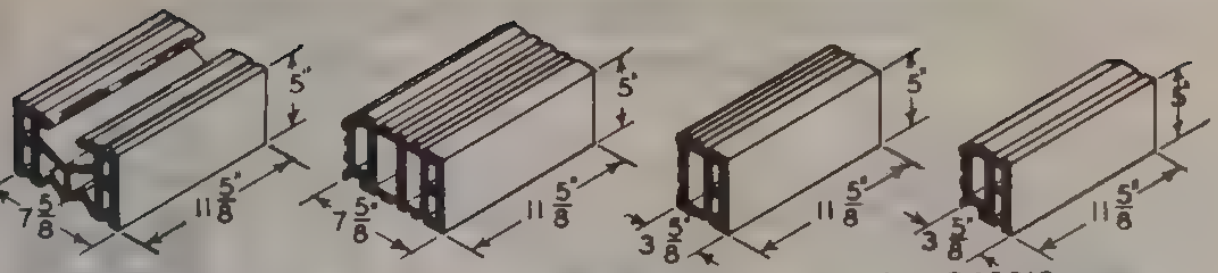
Labor laying 4"x12" unit wall tile:

Size of Tile	No. Laid per 8-Hr. Day	Labor Hours per 100 Pieces Mason	Labor	No. Sq. Ft. 8-Hr. Day	Labor Hours per 100 Sq. Ft. Mason	Labor
$3\frac{5}{8}$"x$3\frac{5}{8}$"x$11\frac{5}{8}$"	170-200	4.33	4.33	57-67	13.0	13.0
$7\frac{5}{8}$"x$3\frac{5}{8}$"x$11\frac{5}{8}$"	150-170	5.0	5.0	50-57	15.0	15.0

$5\frac{1}{3}$"x12" units, which include Kwiklay and Dri-Speedwall, have actual face dimensions of 5"x$11\frac{5}{8}$" with $3\frac{5}{8}$" and $7\frac{5}{8}$" thicknesses, although Kwiklay, may vary somewhat in various parts of the country from $4\frac{7}{8}$" to $5\frac{1}{16}$" in height and $11\frac{1}{2}$" to $11\frac{3}{4}$" in length. Units can be figured to lay up 225 tile per 100 sq. ft. of wall and require 8.5 cu. ft. of mortar for 4" walls and 9.25 for 8" walls, the latter varying as to actual face size.

Labor laying $5\frac{1}{3}$"x12" unit tile:

Size of Tile	No. Laid per 8-hr. Day	Labor Hours per 100 Pieces Mason	Labor	No. Sq Ft. per 8-Hr. Day	Labor Hours per 100 Sq. Ft. Mason	Labor
$3\frac{5}{8}$"x5"x$11\frac{5}{8}$"	175-200	4.25	1.90	80- 90	9.50	4.12
$7\frac{5}{8}$"x5"x$11\frac{5}{8}$"	130-155	5.50	2.50	60- 70	12.25	5.50



SS-8512
SS-8512 (GAUGED)
8" STRETCHER

S125D12
8" DRIP-BOND
STRETCHER

S45K12
4" BOND
STRETCHER

S45D12
4" DRIP JOIST
STRETCHER

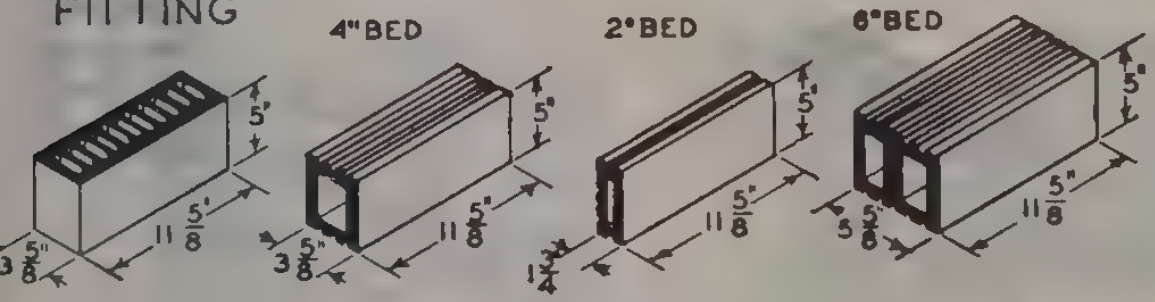
UNIVERSAL FITTING

INTERIOR WALL STRETCHER UNITS

4" BED

2" BED

6" BED



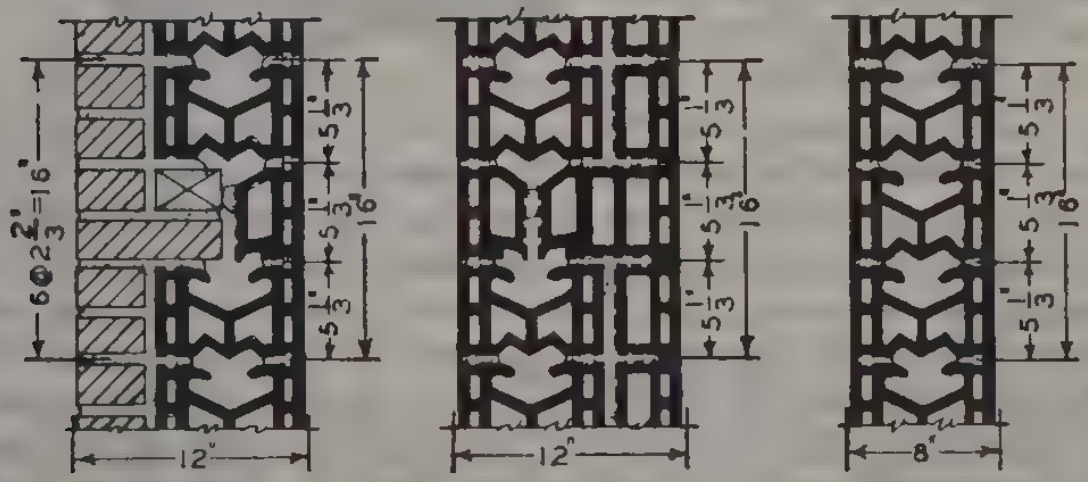
S45

6TC SU
6TCD (SELECT 2 FACES)

6TCA

6TC60 SU

SUPPLEMENTAL SQUARE AND BULLNOSE JAMBS, CORNER, SILL, CAP, LINTEL SHAPES AND FITTINGS, ALSO BULLNOSE STARTERS, CAP AND COPING CORNERS AVAILABLE FOR COMPLETE INSTALLATION AS REQUIRED.



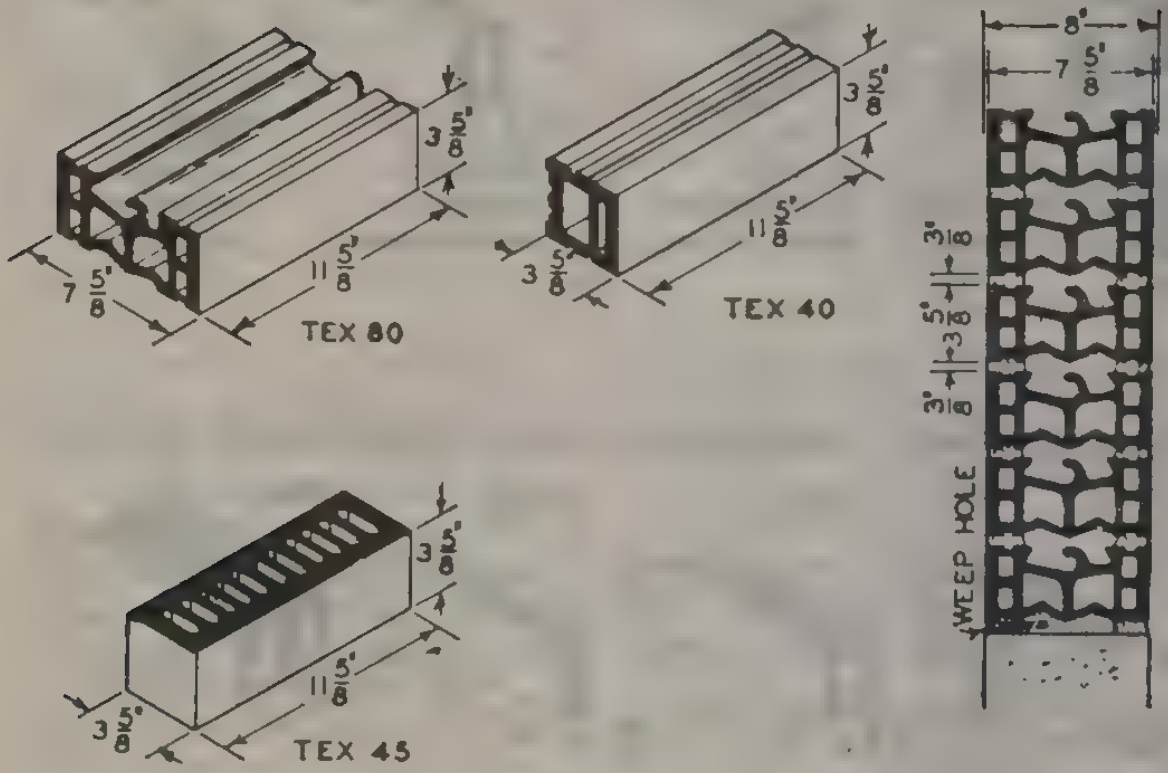
12" BRICK & TILE WALL

12" TILE WALL

8" TILE WALL

Glen-Gery Dri-Speedwall Tile

GLEN-GERY TEX DRI-WALL TILE
(NOMINAL 4X12 FACE SIZE)



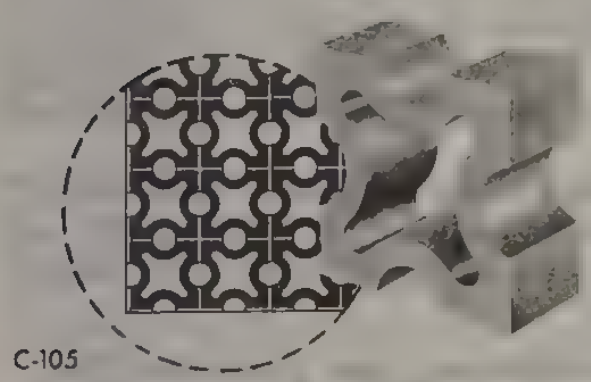
Clay Masonry Shading Devices

With the advent of air conditioning and the growing building activity in the south and southwest, architects have been experimenting with sun controls beyond the usual shades, blinds and drapes. A most effective way of sun control is the egg crate screen wall design which baffles both the low east and west rays of the sun as well as the high direct south rays.

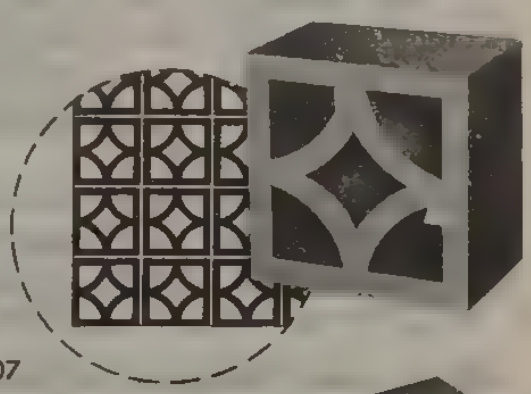
Clay masonry units are available to construct such baffles in both glazed and unglazed finishes and in a large range of sizes, shapes and designs. Selection will depend on the degree of shading desired, the wall thickness necessary to provide structural stability and aesthetic considerations. The following table covers material requirements for most units. Dimensions given are nominal and include allowances for ⅜" to ½" joints. At least 2% should be added for breakage. Mortar allowances include 10% for waste and allow for full head and bed joints, a necessity in exposed walls, but which could be modified for interior decorative screen walls. Glazed solar screen units 4" thick will cost around $5.50 per unit.

Rectangular Sizes				Structural Data		Shading Data		Estimating Data				
Nominal Modular Dimensions in inches*			Specified Dimension in inches			100% Shading		Units	Mortar			
h Face Height	w Face Width	l Length in Wall Thickness	d Shell Thickness	Ratio of Solid Wall Area to Total Wall Area	Approximate Weight per sq. ft. of Wall Area in lb.	Profile Angle β	Bearing Angle γ	No. per sq. ft. of Wall	Cu. ft. per sq. ft. of Wall Area		Cu. ft per 1000 Units	
									½" joints	⅜" joints	½" joints	⅜" joints
4	8	6	⅜	.56	40	23°	49°	4.5	.092	.069	20.3	15.2
4	8	8	⅜	.56	54	17°	40°	4.5	.125	.094	27.8	20.8
4	8	12	⅜	.56	80	12°	29°	4.5	.193	.145	42.5	31.9
8	8	6	⅜	.39	30	49°	49°	2.25	061	.046	27 1	20.3
8	8	8	⅜	39	40	40°	40°	2 25	828	622	36.8	27 6
8	8	12	⅜	.39	60	29°	29°	2.25	.127	.095	56.5	42.4
8	12	6	¾	.375	30	48°	62°	1.5	.051	.382	34.5	26.9
8	12	8	¾	.375	40	39°	54°	1.5	.700	.525	46.6	35.0
8	12	12	¾	.375	60	28°	42°	1.5	.108	.081	72.0	54.0
12	12	6	⅜	34	25	61	61	1 0	042	032	42 0	31 5
12	12	8	⅜	34	33	53	53	1 0	057	043	57 2	43 0
12	12	12	⅜	.34	50	41°	41°	1.0	.880	.66	88.2	66.1

*Manufactured dimensions are ⅛ in. to ½ in. smaller than the nominal modular dimensions shown, depending on the manufacturer



C-105



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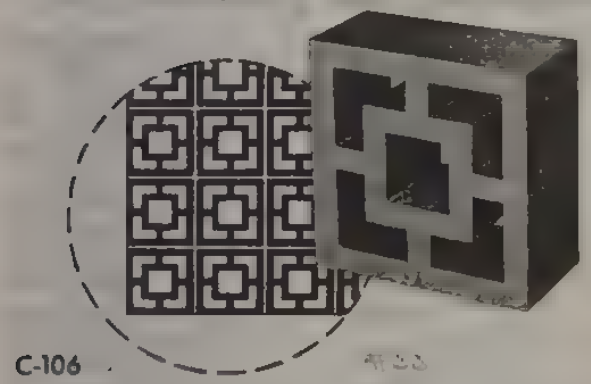

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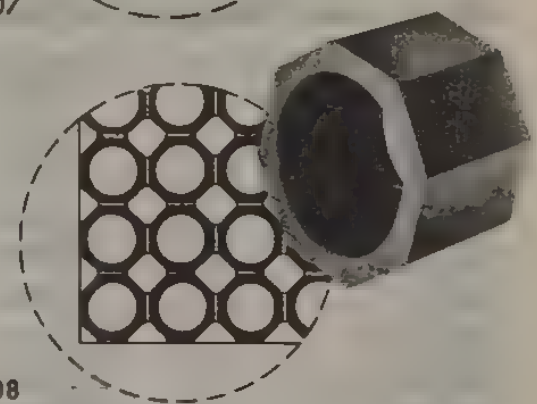


C-108

FOUR PATTERNS OF SOLAR SCREEN TILE

Size: 7⅝ x 7⅝ for ⅜" mortar joints
Thickness: 3⅝", 5$\frac{1}{16}$" and 7¾"

Tile Raggle Blocks

Known also as flashing tile, these units offer a permanent counterflashing at juncture of parapet walls and roofing. Units are nominal 4" deep by 12" long and are an actual 5" high for use with modular brick or 5¾" for use with special size brick. Modular raggle blocks take the place of 3 bricks and are set by

the brick mason as he builds up the wall. Cost is $0.30 a piece for stretcher units, $0.35 for corner units.

Furring and Partition Tile

Furring and partition tile are furnished 12"x12" square and 2", 3", 4", 6", 8", 10" and 12" thick. Each piece of tile covers one sq. ft. of wall.

Furring and partition tile should be estimated by the sq. ft. taking the area of all walls to be furred or partitions to be constructed, stating the number of sq. ft. of each size tile.

Make deductions in full for all openings, and add a small percentage (2 to 5%) to cover waste and breakage, although this should be largely overcome by the mortar joints, unless a very poor grade of tile is used.

A non-modular tile is normally 12"x12" in size, although this varies somewhat on account of burning in the kilns. Allowing ½" for mortar joints, makes 12½"x12½", covering 156 sq. in. or 1-1/12 sq. ft. so unless the breakage is unusually large, the mortar joints should offset it.

If modular size tile are used, then the tile would be 11½"x11½" and allowing for a ½" mortar joint, each tile would cover one sq. ft. of area. Where modular size tile are used, add about 5 percent for waste and breakage.

Sizes and Weights of Standard Furring and Partition Tile

Size in Inches	Type of Surface	Weight per Piece	Price per 1000*
1½x12x12	Split	7.5#	$125.00
2x12x12	Split	8#	150.00
2x12x12	Scored	14#	216.00
3x12x12	Scored	15#	216.00
4x12x12	Scored	16#	230.00
5x12x12	Scored	19#	265.00
6x12x12	Scored	22#	315.00
8x12x12	Scored	30#	429.00
10x12x12	Scored	35#	500.00
12x12x12	Scored	40#	600.00
3x12x12	Smooth	15#	225.00
4x12x12	Smooth	16#	250.00
5x12x12	Smooth	19#	315.00
6x12x12	Smooth	22#	329.00
8x12x12	Smooth	30#	450.00

*Above prices f.o.b. factory. Add for freight and trucking.

Note: Standard weights permit a tolerance of 5% over or under standard weights.

Note: No dimensions shall be more than 3% over or under the dimensions of standard sizes.

Quantity of Hollow Tile in a Carload.—The average carload is 50,000 to 60,000 lbs. or 25 to 30 tons, although it is possible to place 80,000 lbs. or 40 tons in most cars.

Cu. Ft. of Mortar Required to Lay 100 Sq. Ft. of Tile
Based on covering one bed and one end joint.

Size of Tile	Cells Laid	Cu. Ft.	Size of Tile	Cells Laid	Cu. Ft.
2"x12"x12"	Horizontal	1.30	6"x12"x12"	2" moisture stop	3.30
3"x12"x12"	Horizontal	1.60	8"x12"x12"	2" moisture stop	4.60
4"x12"x12"	Horizontal	2.00	10"x12"x12"	4" moisture stop	5.25
6"x12"x12"	Horizontal	2.60	12"x12"x12"	6" mosture stop	6.00
8"x12"x12"	Horizontal	3.25	10"x 8"x16"	building block	5.75
10"x12"x12"	Horizontal	4.00	6"x12"x 8"		3.50
12"x12"x12"	Horizontal	5.00	8"x12"x 8"		5.80

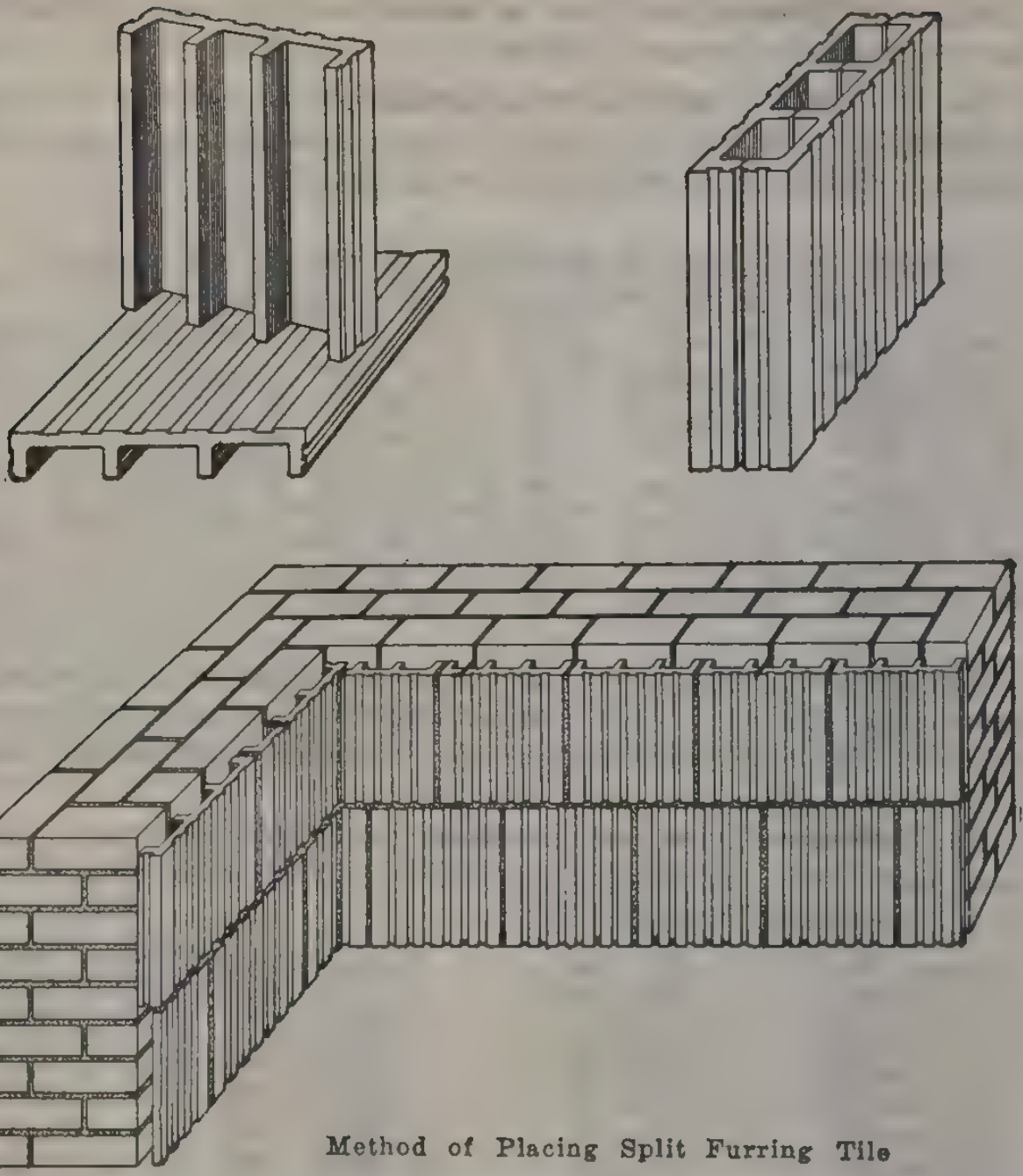
Unloading Hollow Tile From Cars.—The labor cost of unloading hollow tile from cars and placing them in piles will vary with the size and weight of the tile, distance of the wheel and kind of wheelbarrows used.

The following costs are based on using tile barrows, which hold more than an ordinary wheelbarrow, wheeling them 35 to 50 ft. and placing in piles.

Size of Tile in Inches	No. Pcs. Per Load	Number Pieces per 8-Hr. Day	Labor Hrs. per 100 Sq. Ft.
3"x12"x12"	12-16	1,000—1,200	0.75
4"x12"x12"	12-15	900—1,100	0.80
5"x12"x12"	10-14	800—1,000	0.88
6"x12"x12"	9-12	700— 900	1.00
8"x12"x12"	8-10	600— 700	1.25
10"x12"x12"	6- 8	500 —600	1.50
12"x12"x12"	6- 8	500— 600	1.50

If power buggies are used for unloading tile, the size of the loads can be greatly increased, lowering costs 10 to 20 percent, depending upon size of power buggy used and length of haul.

Hauling Hollow Tile From Cars to Job.—A truck should carry 1 to 10 tons of tile per load and travel at 10 to 12 miles per hr. Under average conditions figure about $2.50 to $3.00 per ton for hauling tile by motor truck.



Method of Placing Split Furring Tile

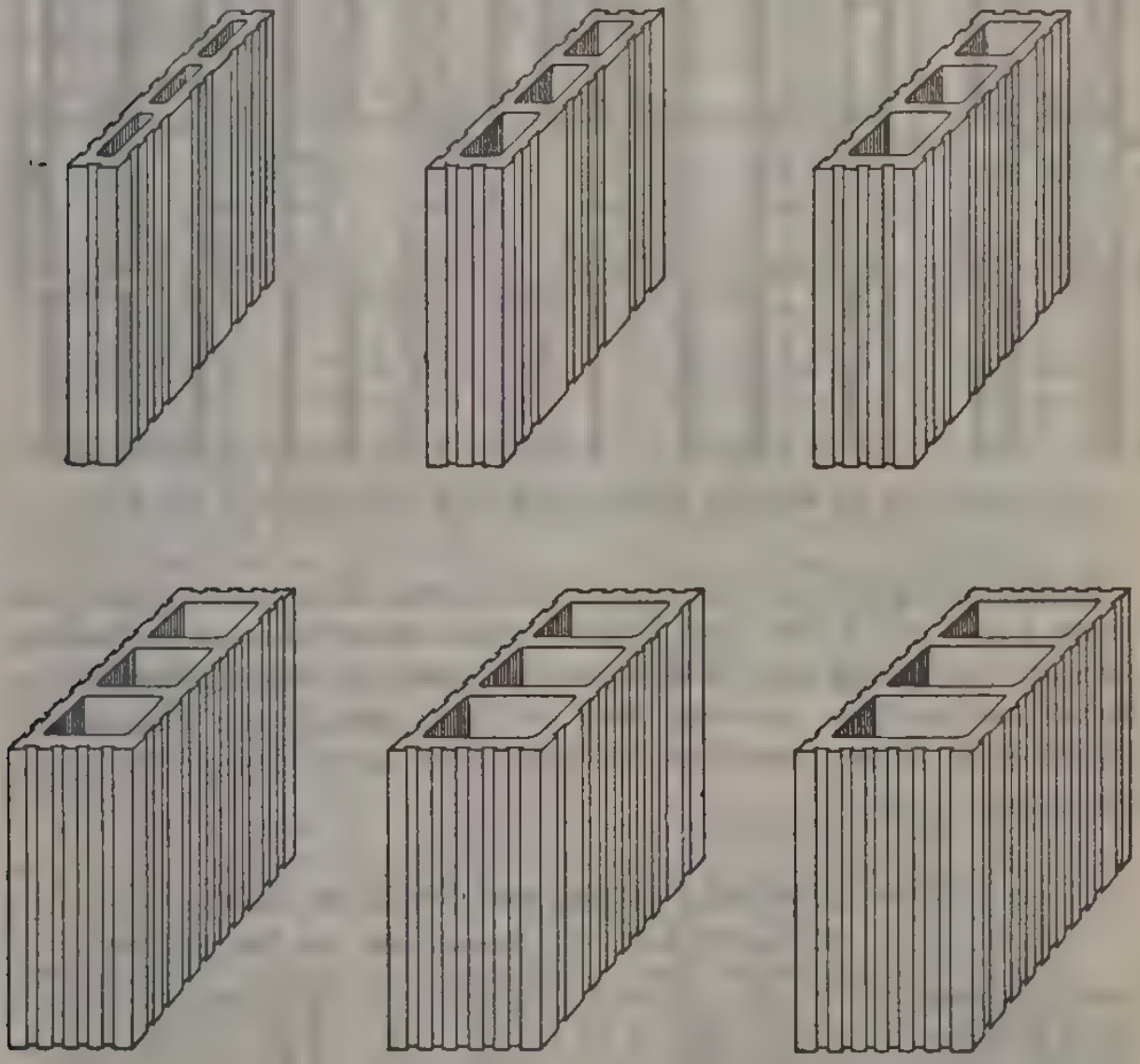
Labor Handling and Setting Hollow Tile Furring and Partitions.—The labor cost of handling and setting hollow tile furring and partition tile will vary with the length and height of the walls and floor plan, i.e., whether straight walls having an average number of openings or short and irregular walls having an unusually large number of pilasters, openings, etc.

The height of the wall has considerable bearing on the labor costs, as one scaffold is sufficient for a 10′-0″ or 11′-0″ wall, but higher walls require two or more scaffolds, and additional labor. Handing the tile from the floor to the second scaffold requires the services of one extra man.

Bricklayers usually set all furring and partition tile but in the larger cities there are masons who specialize in tile setting.

The labor handling and wheeling tile, building scaffold and helping bricklayers will average about 1 hr. labor time to each hour bricklayer time. If partitions are two or more scaffolds high, figure 1¼ to 1½ hrs. labor time to each hour mason time.

It is not generally practicable to use 2″ tile for partitions, except for closets, shafts, etc.



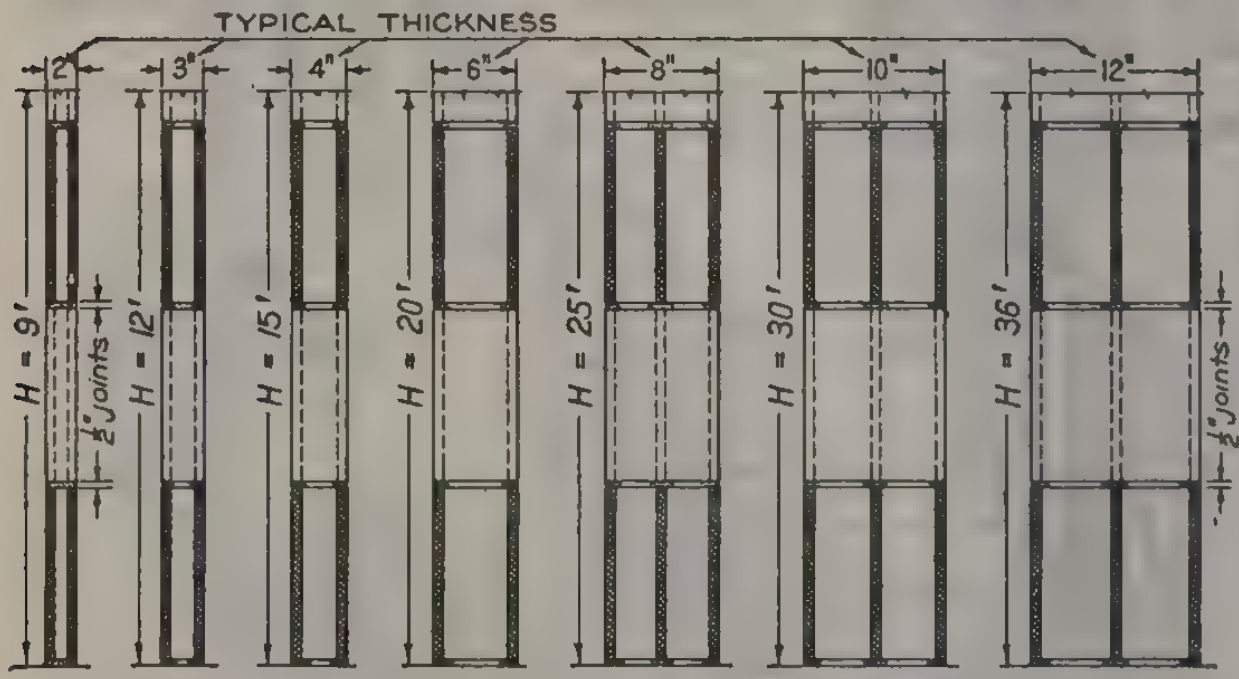
Hollow Clay Partition Tile

Partitions of 3″ tile can be safely used up to 12′-0″ in height; 4″ to 16′-0″, and 6″ to 20′-0″.

In office buildings it is good practice to have all main corridor partitions and stairway and elevator enclosures of 4″ tile and partitions between rooms of 3″ tile. Partitions should be bonded where meeting and anchored to wood bucks or brick walls by

using ten-penny nails or metal wall ties in each second joint.

Tile should be set on end, except top course, which may be set on side.



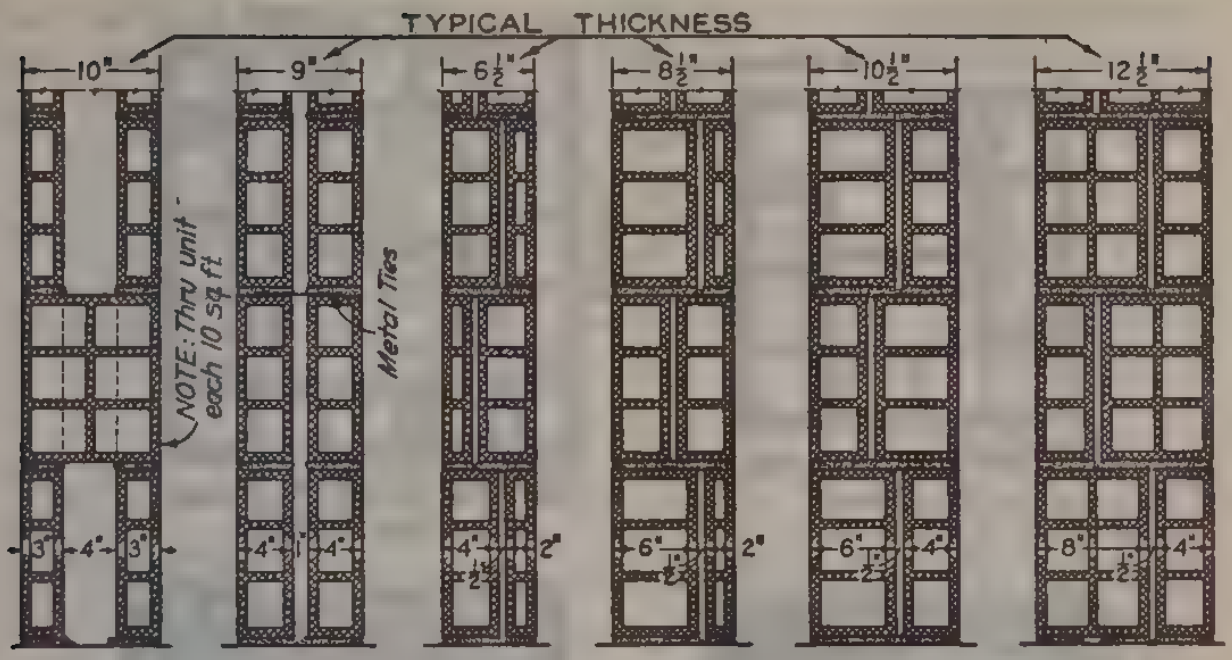
Tile Partitions of Various Thicknesses and Safe Heights for Same.

Split furring tile are 1½" or 2" thick and 12" square. The ribs being set against the wall form an air space which checks the passage of moisture. Where walls must be straightened or furred out to line with the face of piers the 2" tile cannot be used but 3" or 4" partition tile should be used, depending upon the ceiling height.

Labor Setting Furring and Partition Tile

Size of Tile	No. Sq. Ft. Set per 8-Hr. Day	Labor Hrs. per 100 Sq. Ft. Mason	Labor	Engr.**
2"x12"x12"*	200-225	3.75	3.75	0.25
2"x12"x12"	165-180	4.50	4.50	0.25
3"x12"x12"	200-225	3.75	3.75	0.25
4"x12"x12"	190-215	4.00	4.00	0.25
5"x12"x12"	170-200	4.25	4.25	0.38
6"x12"x12"	155-180	4.75	4.75	0.38
8"x12"x12"	120-145	5.75	5.75	0.50
10"x12"x12"	110-120	7.00	7.00	0.50
12"x12"x12"	90-105	7.50	7.50	0.50

*Split furring tile. **Use only if tile have to be hoisted.



Method of Building Tile Partitions of Various Thicknesses.

Tile Partitions with Wire Mesh Reinforcing Between Courses.—Where it is necessary to place a strip of wire mesh reinforcing between each course of tile, add 10% to above labor costs.

Tile Girder and Column Covering

The purpose of beam, girder and column covering is to place a fire retardant over the structural steel frame of buildings and to provide a surface on which to plaster. This goes under the general name of "Fireproofing of Steel."

Structural steel columns are economically protected by encasing them with at least 3" of hollow tile. Some jobs require plain square tile or bullnose tile where corners are to be rounded.

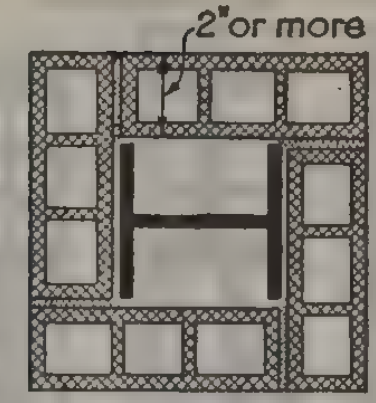
The labor cost of setting tile column fireproofing will vary with the size and height of the column, scaffolding, etc. The smaller the column the higher the labor cost per sq. ft. of surface on account of the high ratio of corners to total area.

Labor Setting Tile Fireproofing for Round or Square Columns

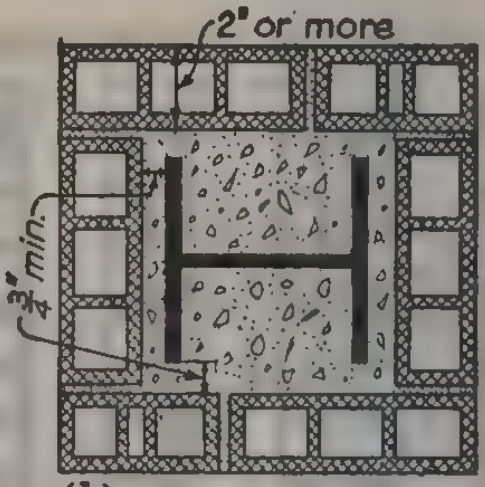
Shape of Column	Size of Column	No. Sq. Ft. Set per 8-Hr. Day	Labor Hrs. 100 Sq. Ft. Mason	Labor	Engr.*
Square or Oblong	12" to 18"	145-190	4.75	4.75	0.25
Square or Oblong	24" to 36"	165-210	4.25	4.25	0.25
Round	16" to 20"	125-150	6.25	6.25	0.25
Round	24" to 28"	155-180	4.75	4.75	0.25

*Add hoisting engineer time only if required.

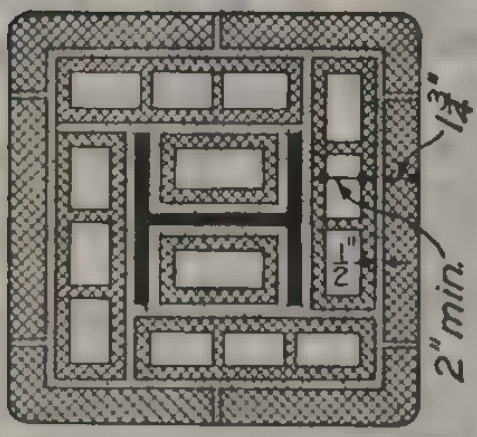
Beam and Girder Covering.—When estimating the quantities of tile required for fireproofing steel beams and girders, it is



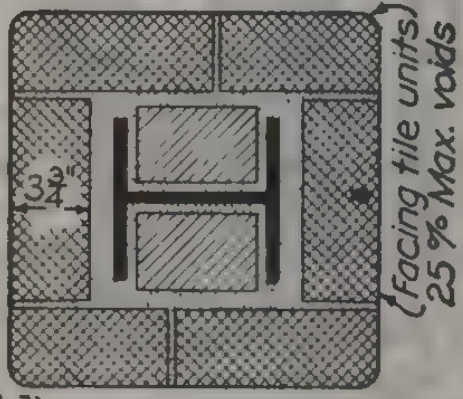
(a) TWO HR. RATING
(NO FILL)



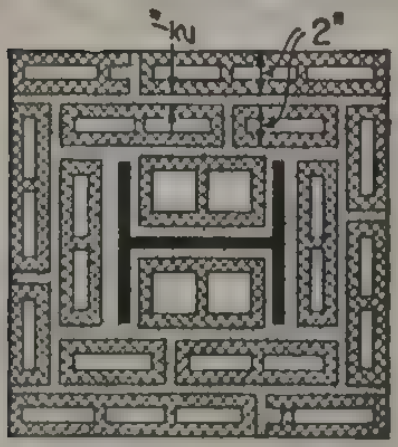
(b) THREE HR. RATING
(CONCRETE FILL)



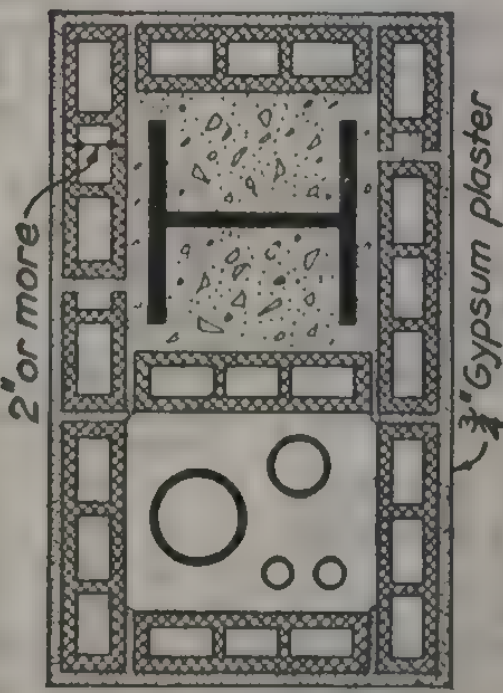
(c) FOUR HR. RATING
(TILE FILL)



(d) FOUR HR. RATING
(BRICK FILL)



(e) FOUR HR. RATING
(TILE FILL)



(f) FOUR HR. RATING
(CONCRETE FILL)

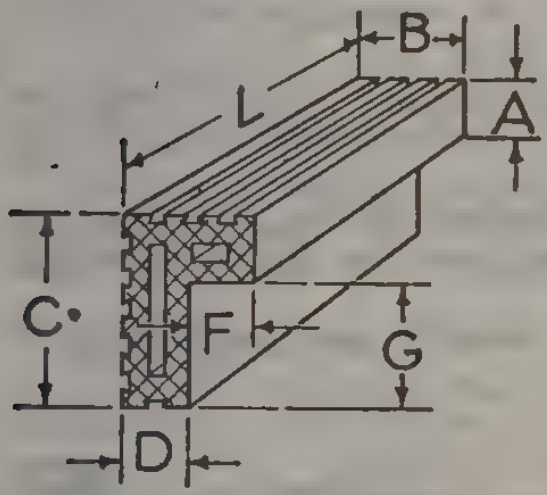
Tile Column Covering.

advisable to lay out the work beforehand to see just what sizes and shapes of tile will be required for each member.

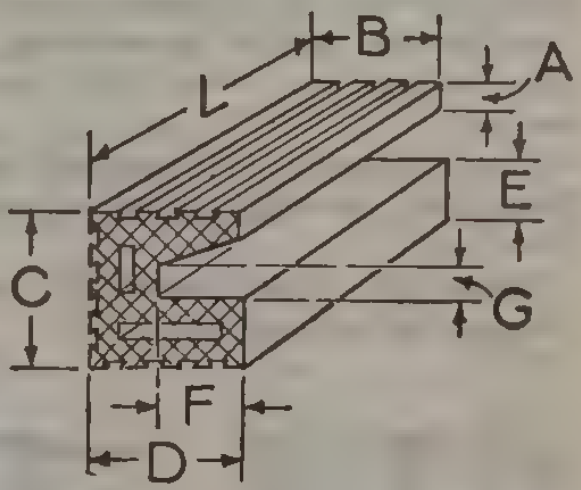
The illustrations show the different shape tile and the combinations in which they may be used in fireproofing any steel members.

Table of Sizes and Weights of Tile Beam and Girder Covering

Note: Clips and angles are 12" long. A percentage of halves is shipped with each order.



(a) ANGLE



(b) CLIP

Unit No.	Sq. ft. outside measure	Weight per piece	A	B	C	D	E	F	G
		lb.							
G25	.70	14	¾	3⅞	4	4½	2	2½	½
G30	.75	15	⅞	4¼	4¼	4¾	2	3	⅞
G35	.80	16	¾	4¾	4¾	5½	2	3½	1
G40	.85	17	¾	4¾	4¾	6	2	4	1
G45	.90	18	¾	4¾	4¼	6½	2	4½	1
G46	.95	19	¾	4¾	4¾	6⅝	2	4⅝	1½
G50	.95	19	¾	4¾	4¼	7	2	5	1
G55	1.00	20	¾	4¾	4½	7½	2	5½	1¼
G60	1.05	21	1	5½	4⅝	8	2	6	1⅜
G70	1.16	23	1	6	4⅞	9	2	7	1½
G75	1.33	29	2	7½	6⅜	9½	2	7½	2⅜
G70	1.40	32	2	8	6⅞	10	2	8	2⅞
L26	.90	18	2	4	8½	2	...	2	6½
L43	.65	13	2	6	5	2	...	4	3
L46	.95	19	2	6	8½	2	...	4	6½

How to Select and Order Proper Clip and Angle Tile for Beam and Girder Covering.—To figure the exact sizes of tile required for fireproofing any members, proceed as follows:

Obtain the width of the beam flange, either by field measurement or from manufacturer's handbook.

Select from the following table clip tile having the "F" dimensions nearest to ½ the width of the flange.

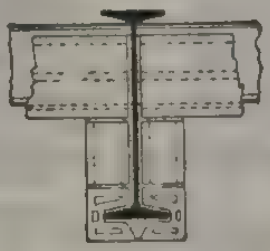
Figure two pieces of clip tile for each lin. ft. of beams when the flange is covered on both sides. Example: A beam having a flange 6¼" wide will require a G-30, since ½ of 6¼" is 3⅛"; and G-30 has "F" dimensions equal to 3".

Angle tile should be selected so that the "G" and "F" legs are long enough to cover the special condition for which it is needed.

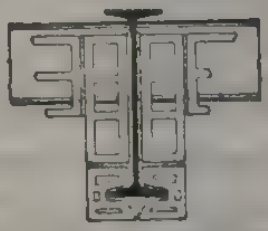
The following is a general description of the various types illustrated, giving members required per lin. ft. of covering, labor, etc.

Type "A". Consists of 2 pcs. of shoe tile on lower flange of I-beam (2 members).

"A" Shoe Tile Fireproofing



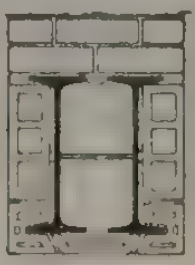
"B" Shoe and Web Tile Fireproofing



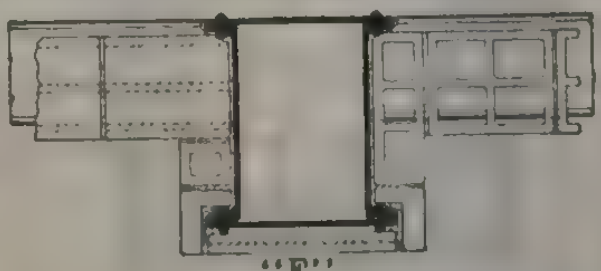
"C" Shoe and Web Tile Fireproofing

"D" Shoe Tile at Top and Bottom of Beam

Type "B". Consists of 2 pcs. of shoe tile on lower flange of I-beam and 2 pcs. of 3"x6"x12" tile to build up to under side of floor (4 members).



"E"



"F"

Shoe and Soffit Tile Fireproofing for Box Beams and Girders.

Type "C". Consists of 2 pcs. of shoe tile on lower flange of I-beam and 2 pcs. of 3"x12"x12" tile to protect the web of the beam (4 members).

Type "D". Consists of 2 pcs. of shoe title on both top and bottom of I-beam and 3"x12"x12" tile on both sides to protect web of beam (6 members).

Type "E". Consists of 2 pcs. of shoe tile and soffit member and 2 pcs. of 3"x12"x12" tile to protect both sides of box girder (5 members).

Type "F". Consists of 2 pcs. of angle tile and 1 pc. of 3" book tile held in place by steel hangers and 1 pc. of 3"x3"x12" tile on one side of box girder and 1 pc. of 3"x12"x12" tile on other side (5 members).

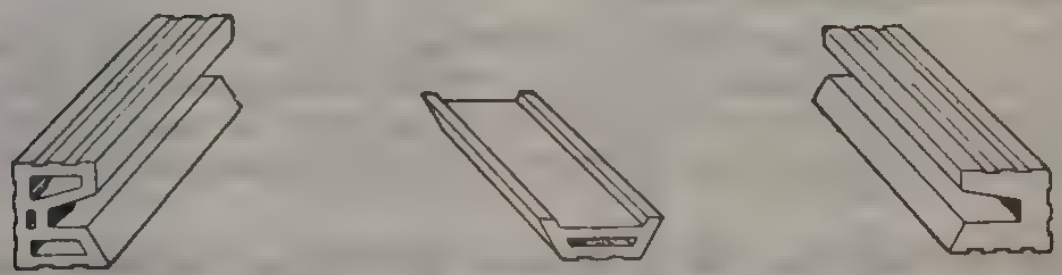
Labor Fireproofing Beams and Girders.—The labor cost of fireproofing steel beams and girders will vary with the sections required per lin. ft. of covering, the accessability of the work, etc.

Labor Setting 100 Lin. Ft. Tile Beam and Girder Covering

Type of Fireprf'g.	No. Lin. Ft. Set per 8-Hr. Day	Labor Hrs. per 100 Lin. Ft. Mason	Labor	Engr.*
"A"	110-135	6.5	13.0	0.25
"B"	75- 90	10.0	20.0	0.25
"C"	55- 80	13.0	26.0	0.50
"D"	40- 50	18.0	36.0	0.50
"E"**	65- 80	11.0	22.0	0.25
"E"***	75- 90	10.0	20.0	0.25
"F"	40- 50	18.0	36.0	0.50

*Add hoisting engineer time only if required.

**Shoe and soffit tile only. ***Add for covering sides with 3"x12"x12" tile.



Shoe and Soffit Tile Covering.

Covering the Sides of Deep Steel Beams and Girders.—Where steel beams, girders or trusses 2'-0" to 10'-0" deep are covered with shoe tile on the bottom flange and the sides or "webs" of the beams covered with 3" or 4" partition tile, the quantities and costs should be estimated as follows: Estimate the quantity of shoe and soffit tile required to cover the bottom

flange of the beam and then figure the number of square feet of partition tile required to cover the sides or "webs."

The labor costs should be figured as given above for shoe and soffit tile and the sides as given for partition tile.

GYPSUM TILE PARTITIONS AND FIREPROOFING

Gypsum tile are used for partitions and column fireproofing. They are 12"x30" in face dimensions. The large units are light in weight and require a minimum of labor for erection.

Estimating Quantities of Gypsum Tile.—Gypsum tile should be estimated by the sq. ft. taking the area of all walls or partitions and making deductions in full for all openings. Gypsum tile are easily handled and may be cut with an ordinary hand saw, reducing waste to a minimum.

The average mortar joint is ⅜" to ½" thick.

Sizes and Weights of Gypsum Partition and Furring Tile

Size of Tile		For Ceiling Heights Up To	Weight per Sq. Ft. Lbs.	Cost per 1000
2" Solid	2"x12"x30"	10'-0"	10.0	$225.00
3" Hollow	3"x12"x30"	13'-0"	10.0	200.00
4" Hollow	4"x12"x30"	17'-0"	13.0	225.00
6" Hollow	6"x12"x30"	30'-0"	19.0	365.00

Cu. Ft. of Mortar Required to Lay 100 Sq. Ft. of Gypsum Partition Tile.

Width of Mortar Joint in Inches	Thickness of Gypsum Tile in Inches 2-in.	3-in.	4-in.	6-in.
¼	1	1½	2	3
⅜	1½	2	2½	3½
½	2 *	2½*	3 *	4 *

*Quantities ordinarily used.

Note: Mortar quantities determined through actual experience and includes waste due to dropping, filling around pipe, etc.

Gypsum partition tile cement should always be used for laying up gypsum tile to obtain a secure bond and consequently a rigid wall.

Cost of One Cu. Yd. of Mortar for Laying Gypsum Tile

Mixed in the proportions of 1 part partition tile cement plaster and 3 parts clean, sharp sand, by weight.

	Rate	Total	Rate	Total
900 lbs. partit. tile cement.	$.....	$.....	$1.45	$13.05
1 cu. yd. sand.....	.....	.....	4.05	4.05
Cost per cu. yd.....		$.....		17.10
Cost per cu. ft.....		.....		.633

To obtain the cost of sufficient mortar to lay 100 sq. ft. of gypsum tile of any thickness, refer to table giving the number of cu. ft. required and multiply by the cost per cu. ft. Example: Find the cost of sufficient mortar to lay 100 sq. ft. of 4″ tile with ⅜″ mortar joints. The table gives 2½ cu. ft. 2½ × $0.633= $1.58 per 100 sq. ft.

Labor Setting Gypsum Tile.—When laying gypsum tile a man sets 2½ sq. ft. at a time but on account of the greater footage of tile set, it requires more labor time handling and getting them to the mason.

Gypsum tile are set by bricklayers or tile setters (bricklayers who specialize in tile setting) and the labor costs will vary with the experience of the men setting them. There are concerns which specialize in the erection of gypsum tile partitions and fireproofing, and their workmen are skilled in this branch of work. Naturally they set more tile per day than a bricklayer, who lays brick today, clay tile tomorrow and gypsum tile the day after. To offset this increased labor efficiency, it is necessary to add their overhead expense and profit, so the total costs will probably offset one another.

Experienced tile setters should set 15 to 25 percent more tile than inexperienced men.

Labor Setting Gypsum Partition Tile

Size of Tile in Inches	No. Sq. Ft. Set per 8-Hr. Day	Labor Hrs. per 100 Sq. Ft. B'layer	Labor	Engr.*
2″ Partition	250-300	2.91	2.75	0.25
3″ Partition	220-260	3.34	3.00	0.25
4″ Partition	195-235	3.72	3.50	0.25
6″ Partition	175-215	4.10	3.75	0.50
2″ Column	200-230	3.72	3.00	0.25
3″ Column	160-190	4.57	4.00	0.25
		Tile Setter	Labor	Engr.*
2″ Partition	300-350	2.46	2.75	0.25
3″ Partition	260-300	2.86	3.00	0.25
4″ Partition	240-280	3.08	3.50	0.25
6″ Partition	215-255	3.41	3.75	0.50
2″ Column	240-275	3.11	3.25	0.25
3″ Column	190-230	3.81	4.00	0.25

*Add hoisting engineer time only if required.

Free standing furring is anchored to the exterior wall either by imbedding corrugated metal wall ties in the exterior wall of sufficient length to be imbedded later in the joints between the tile, or by driving 10d cut nails through the tile into the exterior wall.

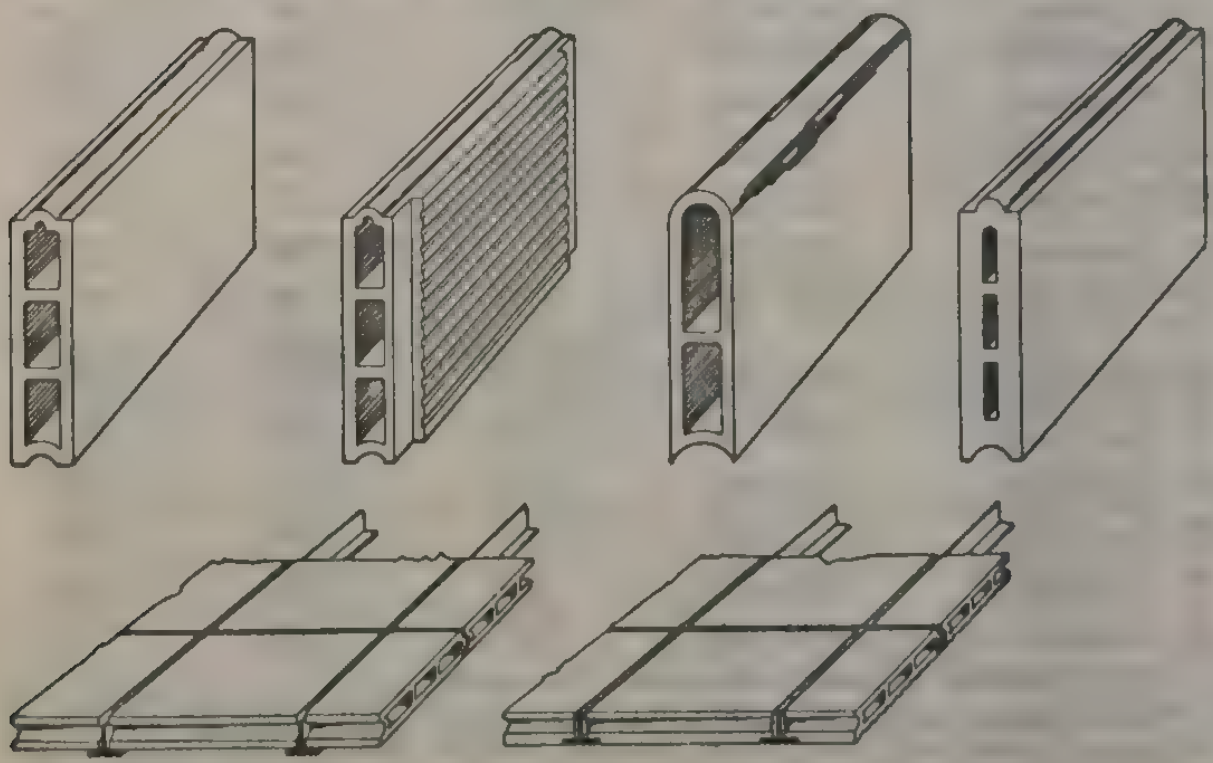
TILE ROOF CONSTRUCTION

There are several types of hollow clay, gypsum and cement tile used for roof construction. Roofs of this type are especially desirable where the underside of the roof must be perfectly dry and free from condensation.

Book Tile Roof and Ceiling Construction

On account of their shape these tile are called "book tile", and they are made especially for roofs to be covered with concrete, tar and felt or any composition roofing. They are furnished in any length from 3"x12"x18" to 3"x12"x24", weigh 18 lbs. per sq. ft. and are made with a tongue or lip so that one tile slips into the other forming a continuous bond. Book tile should be laid in portland cement mortar and it requires 1½ cu. ft. of mortar per 100 sq. ft. of tile.

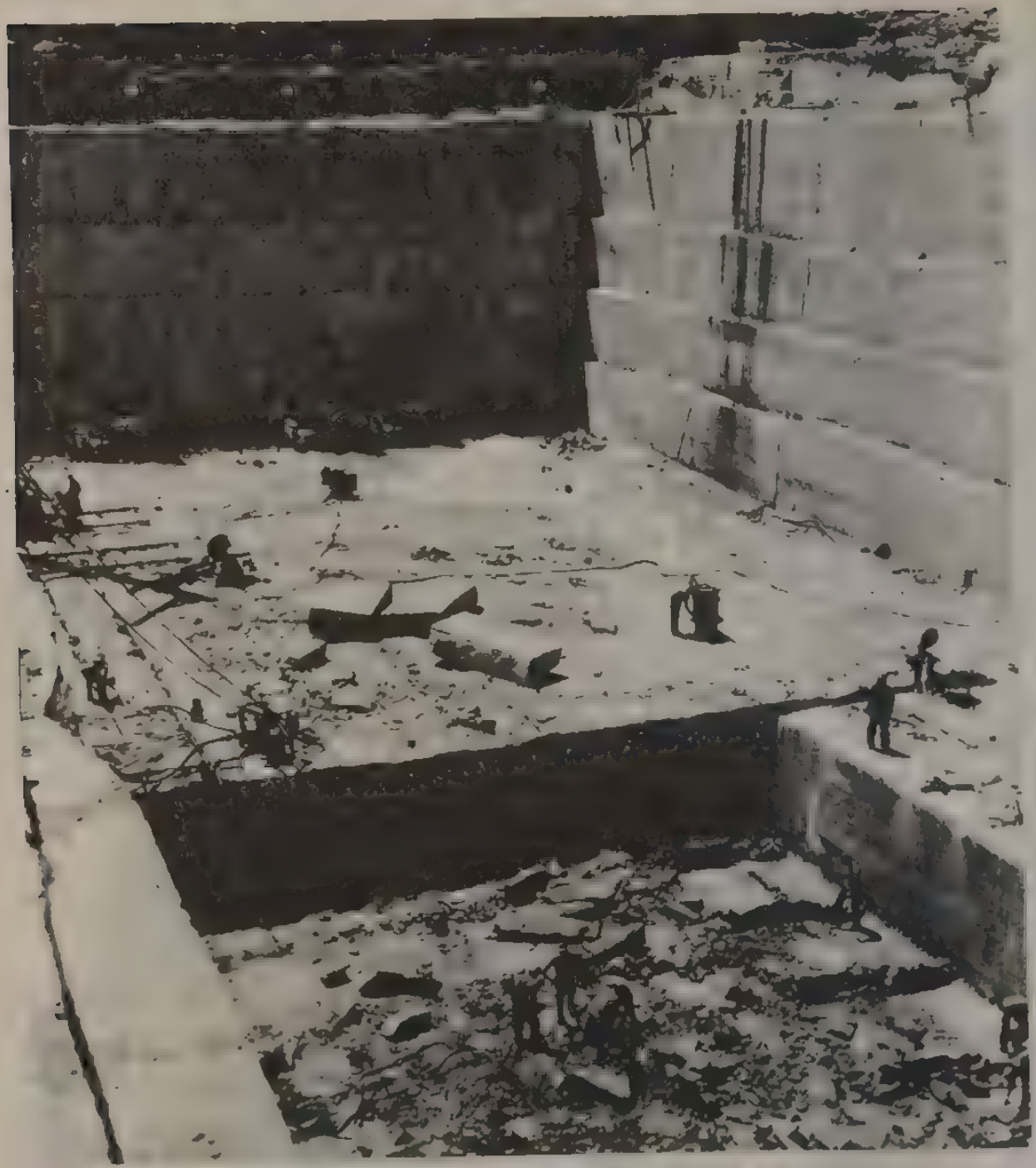
Lightweight T irons, 2¼"x2¼" and weighing 4.1 lbs. per lin. ft. should be used to support the book tile, as shown in the accompanying illustration. The book tile are then laid to rest on the bottom flanges of the T beams and form a continuous roof.



Book Tile Used in the Construction of Ceilings and Roofs.

Labor Setting Book Tile.—A mason should lay 240 to 275 sq. ft. of book tile per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
100 sq. ft. book tile.....		$.....	$.....	$0.50	$50.00
1.5 cu. ft. mortar.....		.....	.....	.82	1.23
Mason	3.1	.....	.....	7.10	22.01
Labor	4.5	.....	.....	5.00	22.50
Hoisting engineer	0.5	.....	.....	6.00	3.00
Cost per 100 sq. ft.....	8.1		$.....		98.74
Cost per sq. ft.....			.....		.99



AN INDIANA LIMESTONE QUARRY

CHAPTER XIV

RUBBLE STONE, CUT STONE, GRANITE AND TERRA COTTA

Stone, being a natural product, varies widely in type and in geographical distribution. Being a very heavy material, except for the lava type stones which have very limited use, the availability of stone locally is of utmost importance to the estimator as transportation costs can become a high percentage of the total cost.

Geologically, stones are classified as follows:

a) Igneous: those formed by cooling molten material inside the earth including granite, trap rock and lava.

b) Sedimentary: those consolidated from particles of decayed rocks deposited along streams and including limestone and sandstone.

c) Metamorphic: those either igneous or sedimentary which have been altered by deep-seated heat and pressure or intrusion of rock materials and including gneiss, marble, quartzite and slate.

Within the industry, the Building Stone Institute divides stones as follows:

a) Bluestone: a hard sandstone, blue gray and buff in color, quarried in New York and Pennsylvania, used for paving, treads, copings, sills and stools, hearth and in random ashlar patterns for walls.

b) Granite: a fine to coarse grained igneous rock, grey, red, green, black or yellow in color, quarried in New England, New York, Virginia, Michigan, Minnesota and Colorado, used for paving, curbing and rubble, mosaic, ashlar and veneered wall construction for almost all building conditions.

c) Greenstone: a metamorphosed stone, a distinctive green in color, quarried in Virginia, and used inside and out for flooring, treads, spandrels and curtain walls, sills, copings, hearths.

d) Limestone: a sedimentary rock, oolitic, dolomitic and crystalline, grey, buff and pinkish in color, quarried in Indiana, Kentucky, Massachusetts, Minnesota, New York,

Alabama, Kansas and Texas, used for wall facings in all patterns, from rubble through the various ashlars to smooth facings in large sheets and for all trim pieces including carved moldings, panels and sculpture.

e) Marble: a metamorphic rock, generally recrystallized limestone, available in a wide range of colors and variegated patterns, quarried in Georgia, Alabama and Vermont, used generally as interior facings (which are covered in Chapter XXII of this book) and much of which is imported, but are increasingly used as exterior veneers on precast concrete panels and as brick sized and random ashlar units for exterior walls.

f) Quartzite: a compact granular rock composed of quartz crystals in a wide variety of colors, many of which are variegated, quarried in Colorado, Tennessee and Utah, and used for paving, ashlar and mosaic wall veneers, copings, sills, hearths and treads. Quartzite is also highly popular as aggregate for precast panels.

g) Sandstone: a sedimentary rock, in warm earth tones from near white to dark browns and reds, quarried in Colorado, Minnesota, Michigan, Indiana, Ohio, New York and Massachusetts, used for wall facings of all types rubble and mosaics, ashlars and smooth sheet facings.

h) Slate: a fine grained metamorphic rock derived from sedimentary rock shale, predominantly gray and blue-black in color but also available in red, green, mottled green, purple, mottled purple and weathering green, quarried in Pennsylvania, Virginia, New York and Vermont, and used in slabs for exterior facings, flooring, paving, treads, bases, sills and stools, copings, fireplace trim and, of course, roofing.

The stone pattern and the type of finish also are of utmost importance to the estimator.

Patterns used in laying up stone work in walls include:

a) Rubble: including uncoursed field stone, polygonal or mosaic and random coursed.

b) Ashlar: including rubble field mixed with coursed ashlar, random range coursed ashlar, random range interrupted coursed, broken range ashlar and coursed ashlar.

c) Panelling: including spandrel and curtain wall units of both natural stone and stone aggregate precast with concrete.

Finishes for stone will vary as to the hardness and evenness of the material, and may be generally classified as natural, rough worked, and smooth.

Natural finishes may be weathered as in field stone, or seam or split faced, when the natural quarry texture is exposed.

Rough finishes are obtained mechanically by cutting with pitching chisels; gang sawing with steel shot or rough chat; plain sawn which still leaves sawn marks; planed finish including those where small particles are plucked after planing to roughen the texture; hammered, hand and machine tooled, where 2 to 10 parallel concave grooved cuts per inch are cut into the exposed surface. A newly devised rough finish for granite is obtained by exposing it to flames.

Smooth finishes include those rubbed wet by hand with carborundum block and water; machine rubbed with carborundum disc; and honed, obtained with a polishing machine and which leaves the stone almost without texture. As this last finish is expensive, it should be limited to interior work or the finest exterior within 30′ of eye range. Granite and marble may be polished smooth.

RUBBLE STONE WORK

Rubble stone work may be estimated by the cu. yd. containing 27 cu. ft. or by the perch containing 24¾ cu. ft. A perch of stone is nominally 16½ ft. long, 1 ft. high and 1½ ft. wide, but is often computed differently in different locations. In many states, especially west of the Mississippi River, rubble work is figured by the perch containing 16½ cu. ft. Before submitting prices on rubble work by the perch, be sure to find out the common practice in your locality.

Cost of Rubble Stone.—The cost of rubble stone will vary with the locality, kind of stone used, distance of quarry from the job, etc.

The method of buying and selling rubble stone also varies with the locality, as in some places it is sold by the ton containing 2,000 lbs. while in others it is sold by the perch containing 24¾ cu. ft. or by the cord containing 100 cu. ft. and weighing 13,000 lbs. which is about 130 lbs. per cu. ft. In some localities it is sold by the cu. yd. containing 27 cu. ft.

Mortar for Rubble Stone Work.—The quantity of mortar required for rubble stone will vary with the size and shape of the stone and the thickness of the walls, but a fair average is 7 to 9 cu. ft. of mortar per cu. yd. of wall. Mortar costs are given under "Brick Masonry."

Cost of Setting Rubble Stone.—When handling and setting rubble stone in walls up to 1′-6″ thick, a mason and laborer should handle and set 70 to 85 cu. ft. per 8-hr. day.

On heavy walls, 2'-0" to 3'-0" thick, a mason should set 100 to 115 cu. ft. per 8-hr. day, and will require about 1½ hrs. labor time to each hr. mason time.

Cost of One Cu. Yd. of Rubble Stone for Walls Over 2'-0" Thick

	Hours	Rate	Total	Rate	Total
27 cu. ft. rubble stone		$.....	$.....	$1.75	$47.25
8 cu. ft. 1:1:6 mortar		.....	.....	.70	5.60
Mason	2.0	.....	.....	7.10	14.20
Labor	3.0	.....	.....	5.00	15.00
Cost per cu. yd.	5.0		$.....		$82.05
Cost per cu. ft.			.....		3.04

Cost of One Cu. Yd. of Rubble Stone for 1'-6" Walls

	Hours	Rate	Total	Rate	Total
27 cu. ft. rubble stone		$.....	$.....	$2.00	$54.00
7 cu. ft. 1:1:6 mortar		.....	.....	.70	4.90
Mason	2.7	.....	.....	7.10	19.17
Labor	2.7	.....	.....	5.00	13.50
Cost per cu. yd.	5.4		$.....		$91.57
Cost per cu. ft.			.....		3.39

Rough faced stone is used in the construction of churches, college and university buildings, fraternity and sorority houses, chapels, residences, etc.

This stone is commonly known as Lannon (Wisconsin), Briar Hill (Ohio), Crab Orchard (Tennessee), as well as other similar stones quarried in different parts of the country and used in the same manner.

The stone is usually furnished in slabs from 4" to 8" thick and 1" to 15" high, depending upon the class of work.

RANDOM ASHLAR

When the stone is to be backed-up with common brick it is usually furnished 4" to 8" thick to bond with the brickwork but when used as a veneer on residences, etc., it is usually furnished 4" thick and is tied to the wall with metal wall ties.

The cost of setting this stone varies widely, depending upon the size of the stone and the amount of cutting required. On some of the more intricate jobs it requires as much mason's time trimming and cutting the stone as is required to set it. The entire success of the use of this random ashlar depends upon the artistic manner in which the work is performed, and the labor costs will be governed accordingly.

Labor time handling stone and helping masons varies widely, depending upon method of handling stone at job, access of material piles, size of stone, etc.

To show the variations in the cost of setting, six different classes of work are described.

Estimating Quantities of Random Ashlar.—Split faced or other finishes of ashlar stone is usually sold by the ton and is furnished with rough beds, backs and joints. The stone weighs 160 to 165 lbs. per cu. ft. and there are 12 to 12½ cu. ft. of stone to the ton.

Stone 4-in. thick produces 36 to 38 sq. ft. of wall to the ton and when laid with a ½-in. mortar joint should lay 40 to 42 sq. ft. of wall.

Stone 5-in. thick produces 29 to 30 sq. ft. of wall to the ton and when laid with a ½-in. mortar joint should lay 32 to 33 sq. ft. of wall.

Where the stone is backed with common brick, the stone is usually furnished 4-in. to 8-in. thick to bond with the brick backing. Based on an average of 6-in. thick for the job, one ton is sufficient for 24 to 25 sq. ft. of wall and when laid with a ½-in. mortar joint should lay 26 to 28 sq. ft. of wall.

Cost of 100 Sq. Ft. of Random Ashlar Used as a Veneer Over Wood Framing and Sheathing, Stone Veneer 4-In. Thick

	Hours	Rate	Total	Rate	Total
2.5 tons split faced ashlar		$.....	$.....	$66.00	$165.00
10 cu. ft. 1:1:6 mortar....		.....	.....	.70	7.00
Mason	24	.....	.....	7.10	170.40
Labor	24	.....	.....	5.00	120.00
Cost per 100 sq. ft.....	48		$.....		$462.40
Cost per sq. ft.....			.....		4.62

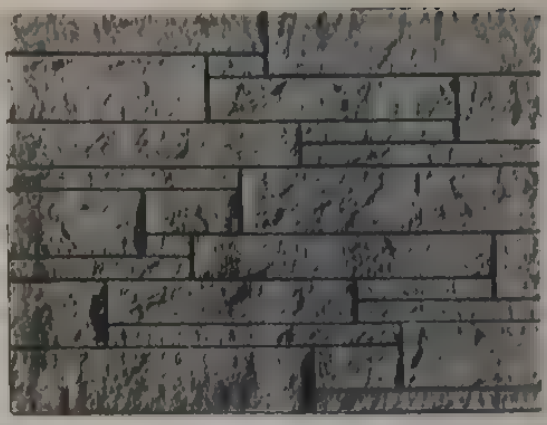
Cost Per Ton of Stone

	Hours	Rate	Total	Rate	Total
1 ton split faced ashlar...		$.....	$.....	$66.00	$ 66.00*
4 cu. ft. 1:1:6 mortar.....		.....	.....	.70	2.80
Mason	10	.....	.....	7.10	71.00
Labor	10	.....	.....	5.00	50.00
Cost per ton.....	20		$.....		$189.80

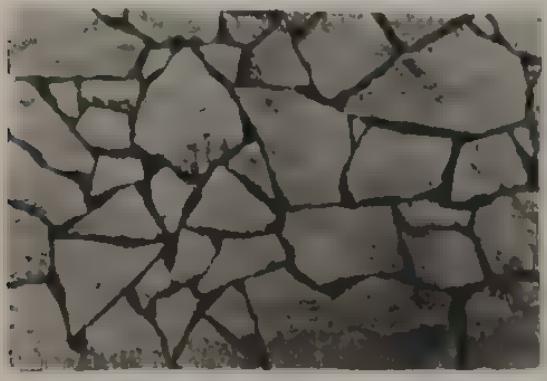
*Always obtain local prices on stone. The above based on Lannon stone in Chicago area.

On work above the second story or where large stones are used, it may require an extra laborer bringing stone to the mason.

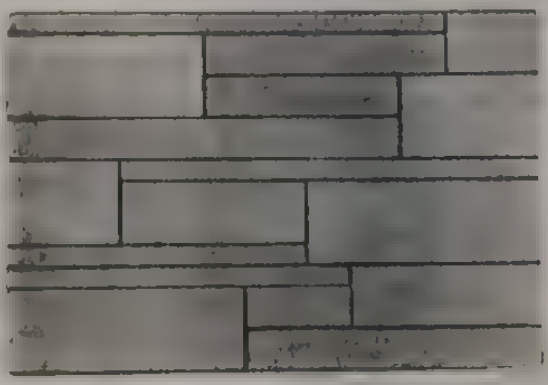
RUBBLE
Thickness: 2" and 2½"
Coverage: 70 sq. ft. per ton



SPLITSTONE
Bed: 3⅝"
Height: 2¼", 5", 7¾"
Coverage: 48 sq. ft. per ton



WEBWALL
Coverage: 30 sq. ft. per ton



CHAT SAWED ASHLAR
Bed: 3" and 4"
Height: 2¼", 5", 7¾", 10½"
Coverage: 3" bed, 60 sq. ft. per ton
4" bed, 40 sq. ft. per ton

HAND PITCHED ROCKFACE
Bed: 3"
Height: 3"
Coverage: 60 sq. ft. per ton

SPLITSTONE WITH CHAT SAWED
Height: Splitstone 2¼"
Chat Sawed 5" and 7¾"
Coverage: 55 sq. ft. per ton

LIMESTONE VENEER PATTERNS

Courtesy of Victor Oolitic Stone Co., Bloomington, Ind.

Cost of 100 Sq. Ft. of Random Ashlar on Straight Walls, Backed Up With Common Brick and Requiring Only End Jointing

Average Thickness of Stone 5 Inches.

	Hours	Rate	Total	Rate	Total
3 tons split faced ashlar..		$.....	$.....	$66.00	$198.00*
12 cu. ft. 1:1:6 mortar...		.....	.....	.70	8.40
Mason	26	.....	.....	7.10	184.60
Labor	26	.....	.....	5.00	130.00
Cost per 100 sq. ft.....	52		$.....		$521.00
Cost per sq. ft.....			.....		5.21

Cost Per Ton of Stone

	Hours	Rate	Total	Rate	Total
1 ton split faced ashlar...		$.....	$.....	$66.00	$ 66.00*
4 cu. ft. 1:1:6 mortar....		.....	.....	.70	2.80
Mason	8.5	.....	.....	7.10	60.35
Labor	8.5	.....	.....	5.00	42 50
Cost per ton.....	17.0		$.....		$171.65

Setting Random Ashlar in Straight Work Requiring Backing, Cutting and Fitting.—When setting random ashlar in fairly straight walls as described above, but where the stone must be backed, and end joints cut on the job, an experienced mason should set stone in 17 to 25 sq. ft. of wall per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Mason	38	$.....	$.....	$7.10	$269.80
Labor	38	.....	.....	5.00	190.00
Cost per 100 sq. ft.	76		$.....		$459.80
Cost per sq. ft.			.....		4.60

The labor time will vary widely according to job conditions, as some jobs may require only one-half as much labor time as mason time, while others may require twice as much.

Setting Random Ashlar in Churches, Chapels, Etc., Where Stone is Cut to Size in Shops.—On churches, chapels, and similar structures having numerous corners, offsets, piers, pilasters, etc., where the stone is all backed in the shop and requires very little cutting and fitting by the masons on the job, an experienced mason should set stone in 25 to 30 sq. ft. of wall per 8-hr. day, at the following labor cost per 100 sq. ft.:

*Always obtain local prices on stone. The above based on Lannon stone in Chicago area.

	Hours	Rate	Total	Rate	Total
Mason	29	$.....	$.....	$7.10	$205.90
Labor	29	.....	.....	5.00	145.00
Cost per 100 sq. ft.	58		$.....		$350.90
Cost per sq. ft.			.....		3.51

Setting Random Ashlar in Churches, Chapels, Etc., Where Cutting and Fitting is Done on the Job.--On churches, chapels, and similar structures having numerous corners, offsets, piers, pilasters, etc., where the rough stone is sent to the job and all backing, jointing and fitting is done by the masons on the job, an experienced mason should set stone in 14 to 18 sq. ft. of wall per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Mason	50	$.....	$.....	$7.10	$355.00
Labor	50	.....	.....	5.00	250.00
Cost per 100 sq. ft.	100		$.....		$605.00
Cost per sq. ft.			.....		6.05

Random Ashlar in Residence Construction. Mr. Walker made an actual study of a residence faced with 4500 square feet of 5" Lannon stone veneer. The stone varied from 1" to 10" high and consisted of one third weathered edge, one third bed face stone and one third rock face stone which was only one to two inches high. Care was taken to produce a natural looking pattern with very little cutting and fitting.

A mason set 34 sq. ft. of stone per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Mason	24	$.....	$.....	$7.10	$170.40
Labor	14	.....	.....	5.00	70.00
Cost per 100 sq. ft.	38		$.....		$240.40
Cost per sq. ft.			.....		2.40

Random Ashlar in Memorial Chapel.--The memorial chapel illustrated is also built of Lannon (Wisconsin) stone, but on account of the numerous corners, pilasters, piers, etc., and the fact that all backing, joining and fitting of stone was done on the job, the labor costs ran rather high, as on work of this kind the time required cutting and fitting the stone is almost as much as the setting time.

On this job, a mason averaged 17 sq. ft. of 8" ashlar per 8-hr. day, at the following labor cost per 100 sq. ft.:

Detail of Random Ashlar Stonework

	Hours	Rate	Total	Rate	Total
Mason	47.00	$.....	$.....	$7.10	$333.70
Labor	40.00	.....	.....	5.00	200.00
Labor foreman	3.75	.....	.....	5.25	19.69
Hoisting engineer	3.75	.....	.....	6.00	22.50
Cost per 100 sq. ft.	94.5		$.....		$575.89
Cost per sq. ft.			.....		5.76

CUT STONE

The cost of cut stone will depend upon the kind of stone used (whether sandstone, limestone or marble), the amount of cutting and hand work necessary, and freight from mill to destination.

Cut stone for exterior use is estimated by the cu. ft. (taking the cube of the largest dimensions), and any special work such as hand cutting, carving, etc., is estimated separately and added to the cost of the plain stone.

When estimating the cost of plain door and window sills, lintels, steps, platforms, copings, etc., the quantities are sometimes estimated by the lin. ft. for sills and coping and by the sq. ft. for platforms, but the cu. ft. method is more generally used.

Mortar Required for Setting Stone.—The quantity of mortar required for stone setting will vary with the size of the stone, width of bed, etc., but as a general thing it will require 4 to 5 cu. ft. of mortar per 100 cu. ft. of stone.

If the stone is to be back-plastered, the quantity of mortar will vary with the thickness of the plaster coat but as most ashlar is 4″ to 8″ thick, it will require the following cu. ft. of mortar per 100 cu. ft. of stone:

Plaster Thickness	Thickness of Stone in Inches		
	4″	6″	8″
¼″	6½	4¼	3¼
½″	13	8½	6½
¾″	19	13	9½

It is customary to use white non-staining portland cement for setting and back-plastering limestone or other porous stone as this prevents stains from appearing on the face of the stone. Never use ordinary portland cement for setting limestone.

Cost of One Cu. Yd. of 1:3 Non-Staining Cement Mortar With ⅛ Part of Hydrated Lime Based on the Cement Volume

	Rate	Total	Rate	Total
2 bbls. Medusa Stone Set cement	$.....	$.....	$8.40	$16.80
100 lbs. hydrated lime....	.....	.....	2.00	2.00
1 cu. yd. sand.....	.....	.....	5.00	5.00
Cost per cu. yd.....		$.....		$23.80
Cost per cu. ft.....		.....		.88

If white sand is used for mortar, figure $10.50 per ton (3,000 lbs. per cu. yd.)

If white cement is specified, figure $15.00 per bbl. If white cement (waterproofed) is specified, figure $16.00 per bbl.

Cost of One Cu. Yd. of Cement-Lime Mortar Consisting of ½ Part Lime, ½ Part Stone Set Cement and 3 Parts Sand

	Rate	Total	Rate	Total
1.25 bbls. Stone Set cement	$.....	$.....	$8.40	$10.50
225 lbs. hydrated lime...	.....	.....	2.00	4.50
1 cu. yd. sand.....	.....	.....	5.00	5.00
Cost per cu. yd.....		$.....		$20.00
Cost per cu. ft.....		.....		.74

If white sand is used for mortar, figure $10.50 per ton (3,000 lbs. per cu. yd.)

If white cement is specified, figure $15.00 per bbl. If white cement (waterproofed) is specified, figure $16.00 per bbl.

Setting Cut Stone.—When estimating the labor cost of handling and setting cut stone, the size of the job should be considered, average size of stone, class of workmanship required and the method of setting, i.e., whether by hand, hand operated derricks or by using a mobile crane, stiff leg, guy or other types of derricks.

Setting Random or Range Ashlar.—On churches, libraries, fine residences, etc., where the stone is sawed to thickness and is set in random or range ashlar consisting of 3″ or 4″ sawed strips with all end joints cut on the job, using an electric carborundum saw, an experienced mason should set 80 to 120 sq. ft. of stone per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Mason cutting	8.0	$.....	$.....	$7.10	$ 56.80
Mason setting	8.0	.....	.....	7.10	56.80
Labor	8.0	.....	.....	5.00	40.00
Cost per 100 sq. ft.....	24.0		$.....		$153.60
Cost per sq. ft....					1.54

Setting Cut Stone by Hand.—On small cut stone jobs consisting of door and window sills, lintels, wall coping, steps and other light stone that can be handled and set by two men without the use of derricks, a stone setter should set 50 to 60 cu. ft. of stone per 8-hr. day, at the following labor cost per 100 cu. ft.:

	Hours	Rate	Total	Rate	Total
Stone setter	14	$.....	$.....	$7.10	$ 99.40
Labor	28	.....	.....	5.00	140.00
Cost per 100 cu. ft.....	42		$.....		$239.40
Cost per cu. ft.....			.....		2.39

Setting Cut Stone Using Hand Derricks.—Where the stone consists of coursed ashlar, sills, lintels, lightweight cornices, copings, etc., which can be handled on stone barrows or rollers and set with a breast derrick, gin pole, or other hand operated derricks, a stone setter should set 80 to 100 cu. ft. of stone per 8-hr. day, at the following labor cost per 100 cu. ft.:

	Hours	Rate	Total	Rate	Total
Stone setter	9	$.....	$.....	$7.10	$ 63.90
Helper	9	.....	.....	5.00	45.00
2 derrickmen	18	.....	.....	5.35	96.30
2 men handling stone	18	.....	.....	5.00	90.00
Cost per 100 cu. ft.	54		$.....		$295.20
Cost per cu. ft.			.....		2.95

Setting Heavy Cut Stone Using Hand Derricks.—On jobs requiring heavy stone, such as thick ashlar, heavy molded courses, cornices, copings, etc., where the stone is hoisted and set using hand operated derricks, a stone setter should set 115 to 140 cu. ft. of stone per 8-hr. day, at the following labor cost per 100 cu. ft.:

	Hours	Rate	Total	Rate	Total
Stone setter	7	$.....	$.....	$7.10	$ 49.70
Helper	7	.....	.....	5.00	35.00
2 derrickmen	14	.....	.....	5.35	74.90
3 men handling stone	21	.....	.....	5.00	105.00
Cost per 100 cu. ft.	49		$.....		$264.60
Cost per cu. ft.			.....		2.65

Setting Cut Stone Using a Power Crane.—On many large jobs it will be possible to set the stone, using a mobile power crane to lift the stone from the ground to the wall.

This method is usually less expensive than setting up and dismantling stiff-leg or guy derricks, as the crane can cover the entire perimeter of the building without any setup or dismantling cost to speak of.

Where the stone can be set in this manner, it will require one operator for the crane, 2 laborers on the scaffold helping to land the stone and set it, 4 or 5 laborers on the ground sorting and handling stone from stock pile to derricks, plus the stone setter.

On a job of this kind, a crew should handle and set 200 to 250 cu. ft. of stone per 8-hr. day, depending upon size of stone being set, at the following labor cost per 100 cu. ft.:

	Hours	Rate	Total	Rate	Total
Crane charge, including fuel	4	$.....	$.....	$15.00	$ 60.00
Crane operator	4	.....	.....	6.75	27.00
Stone setter	4	.....	.....	7.10	28.40
2 helpers on scaffold	8	.....	.....	5.00	40.00
5 men handling stone	20	.....	.....	5.00	100.00
Cost per 100 cu. ft.	40		$.....		$255.40
Cost per cu. ft.			.....		2.55

The above does not include any allowance for scaffold, if a separate scaffold is required for stone setting, add for same.

Setting Cut Stone Using Power Derricks.—On large jobs where it is necessary to use stiff leg or guy derricks for hoisting and handling the stone, the costs will vary with the size and weight of the stone, quantity, and with the method of handling the stone on the ground.

On work of this kind it is usually necessary to use stiff leg or guy derricks, or by having the boom of the derrick placed in a boom seat and bolted to the steel frame of the building. On jobs covering a large area, it will be necessary to use a number of derricks, so regardless of the method used in setting the stone, the cost of setting and removing derricks, hoisting engines, etc., should be estimated separately, as this charge will remain the same whether there are 5,000 or 50,000 cu. ft. of stone to be set.

After the derricks and equipment are in place, a stone setter should set 200 to 240 cu. ft. of stone per 8-hr. day. It will require about 2 laborers helping to land the stone and set it, 4 or 5 laborers on the ground sorting and handling the stone from stock piles to derricks, 3 derrickmen and one hoisting engineer.

In connection with work of this kind, there is always a certain amount of lost time caused by delays in delivery of stone, repairs to derricks and hoisting engines, oiling and attending derricks, moving and raising derricks, inspecting cables, tightening guy lines and many other items that require

Power Crane Used for Setting Stone

attention and which must be charged against the cost of ston setting.

Including contingencies as enumerated above, the labor settin 100 cu. ft. of cut stone should cost as follows:

	Hours	Rate	Total	Rate	Total
Stone setter	4.0	$.....	$.....	$7.10	$ 28.40
2 helpers	8.0	.....	.....	5.00	40.00
3 derrick and signal men	12.0	.....	.....	5.35	64.20
5 men handling stone	20.0	.....	.....	5.00	100.00
Hoisting engineer	4.0	.....	.....	6.00	24.00
Contingencies					
Hoisting engineer	1.0	.....	.....	6.00	6.00
Derrickmen	3.0	.....	.....	5.35	16.05
Laborers	5.0	.....	.....	5.00	25.00
Cost per 100 cu. ft.	57.0		$.....		$303.65
Cost per cu. ft.			.....		3.04

The cost of placing and removing derricks may vary from $1,000.00 to $10,000.00 and should be added to the above costs, depending upon the size of job, number of derricks required, number of "raises", etc.

Pointing Cut Stone.—Cut stone is often pointed at the time the stone is set, as recommended practice today is to strike the joints as the work progresses. Pointing mortar applied afterward is usually of different composition and accordingly of questionable permanency.

However, on some jobs it may be necessary to point all mortar joints with white or other non-staining cement after all stone has been set. The mortar joints may be struck flush or slightly rounded with a jointer, as preferred.

The cost of this work will vary with the size of the individual pieces of stone, as the fewer joints the more surface a tuck-pointer will be able to point per day.

On an average job, a tuck-pointer should point 500 to 600 sq. ft. of surface per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Tuckpointer	1.50	$.....	$.....	$7.50	$11.25
Helper	0.75	.....	.....	5.00	3.75
Cost per 100 sq. ft.	2.25		$.....		$15.00
Cost per sq. ft.			.....		.15

Allow one helper on the ground to each 2 tuckpointers or to each scaffold.

Add for mortar, cartage, scaffold, tuckpointing contractor's social security tax and workmen's compensation insurance, overhead expense and profit.

Random ashlar is usually pointed as the work progresses.

Washing and Cleaning Cut Stone.—After the stone work ha been pointed it will be necessary to wash and clean it, usin a stiff fiber brush and plenty of clean water or soapy water, i necessary, and then rinsed with clean water, which will remov the construction and mortar stains. A wire brush should neve be used, as it tends to produce rust marks in the stone.

On new work or work that is fairly clean, an experienced tuck pointer should wash and clean 600 to 800 sq. ft. of surface pe 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Tuckpointer	1.1	$.....	$.....	$7.50	$8.25
Helper	0.6	.....	.....	5.00	3.00
Cost per 100 sq. ft.	1.7		$.....		$11.25
Cost per sq. ft.			.....		.11

Allow one helper on the ground to each 2 tuckpointers or t each scaffold.

Add for cartage, scaffold, tuckpointing contractor's social se curity tax and workmen's compensation insurance, overhead ex pense and profit.

Carving Sand or Limestone.—The cost of carving cut ston is usually figured from full-size details or models furnished b the architect. This cost will vary with the amount of deta and the method used in carving, i.e., whether performed in th shop before setting or after the stone has been set on the job.

Where you are sure of a first class job of setting, it is mor economical to have the carving done in the shop as all carve work consisting of a number of pieces is set up with woo strips forming the thickness of mortar joints and accuratel fitted before shipping to the job.

Many architects who previously had their carving done on th job are now having it done in the shop before shipment.

Carving Stone by Hand in the Shop.—When carving cut ston for medium priced apartment buildings, stores, factories an other structures requiring just an average grade of workman ship and no fine detail work, a carver should complete 2½ to 3 sq. ft. per 8-hr. day, at the following labor cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Stone carver	2.7	$.....	$.....	$7.10	$19.17

On jobs having fine detail work and requiring first class work manship, a carver should complete 1 to 1½ sq. ft. per 8-hr. da at the following cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Stone carver	7	$.....	$.....	$7.10	$49.70

Carving Stone in the Shop Using Pneumatic Tools.—The u

of air tools will greatly increase the daily output of a stone carver, regardless of the class of workmanship required.

On jobs requiring just an average grade of workmanship and no fine detail work, a carver should complete 5 to 8 sq. ft. per 8-hr. day, at the following labor cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Stone carver	1.5	$.....	$.....	$7.10	$10.65

Where first class workmanship and fine detail is required, a carver should complete 2 to 2½ sq. ft. per 8-hr. day, at the following labor cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Stone carver	4.0	$.....	$.....	$7.10	$28.40

Carving Stone by Hand After It Is Set in the Building.—Where the stone is carved on the job after it has been set in place and where first class workmanship is required, a carver should complete 1 to 1¼ sq. ft. per 8-hr. day, at the following labor cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Stone carver	7	$.....	$.....	$7.10	$49.70

If the carving contains considerable fine detail, add ¾ to 1-hr. per sq. ft.

If outside scaffold is required, add labor time to above.

Carving Stone on the Job Using Pneumatic Tools.—If air tools may be used for carving the stone on the job, a carver should complete 1½ to 2 sq. ft. per 8-hr. day, at the following labor cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Stone carver	4.5	$.....	$.....	$7.10	$31.95

If the carving contains considerable fine detail, add ½ to ¾-hr. per sq. ft.

If outside scaffold is required, add labor time to above.

Cost of Models for Stone Carving.—On the better class of work, clay or plaster models for all carving are usually furnished by the architect or a stipulated sum is allowed for models.

Figuring on a sq. ft. basis, models in clay will run around $20.00 to $30.00 per sq. ft. while plaster models will cost about $30.00 to $40.00 per sq. ft. A small rosette or head cast in plaster will cost about $60.00. The models quite generally cost more than the carving, and often twice as much where models are made for an individual piece. It will often require a week's work for a skilled artisan to produce a carefully made model for a carved plaque or panel, 3'-6" to 4'-0" in diameter.

The sq. ft. price of models should be based on the sq. ft. of

model required and not on the sq. ft. surface of carved stone, as one model may often be used for carving 10 or 15 pieces of stone, or one lin. ft. model of carved molding in plaster may often be used for carving hundreds of lin. ft. of stone.

Carving Marble Column Caps on a University Building.—All of the exterior building marble in this building was furnished from quarries in the northeastern part of Oklahoma.

The marble caps setting on the granite columns as illustrated, were all carved on the job using air tools. Each cap was 4′-0″ sq. 2′-0″ high and contained 32 sq. ft. of surface.

It required 6 weeks' time for a carver to complete one cap, which was at the rate of 0.9 sq. ft. per 8-hr. day and the following cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Stone carver	8.25	$.....	$.....	$7.10	$58.58

The above costs do not include engineer's time operating air compressor, nor any allowance for tools and equipment, which should be added.

Data on Indiana Limestone

Indiana limestone is probably more favorably known and more generally used in all parts of the United States than any other stone used for building purposes. This is doubtless due to its appearance, as well as the ease with which it is worked, its freedom from stratification and cleavage plane, and while it is a sedimentary stone, it is to all intents and purposes a free stone, having about equal strength in all directions.

It is used for the exterior facings of buildings, as well as all kinds of trimmings, such as sills, lintels, copings, steps, platforms, etc.

Indiana limestone can be produced in any reasonable quantity and size. A vast amount of this stone is cut ready to place in the building by the mills located adjacent to the quarries, but the rough quarry blocks and sawed slabs may be shipped to any locality where the proper facilities are available and be cut by mills located near the job. In fact, about 60 percent of the total annual output of the quarries is cut by local plants throughout the country.

Kinds of Indiana Limestone.—Indiana limestone is furnished in a variety of different grades and color-tones, a brief summary of which is given below:

Select stock is uniform in color and texture, more so than is required for ordinary building construction. It is recommended for entrance work and those portions of a building within ready range of vision, carving, interior and other exceptional uses.

Standard stock is sound stone with a range of variation in color shades and texture not found in Select but necessarily confined within limits that make it impossible to determine at a distance of a few feet whether it is Standard or Select stock. In fact the capillary attraction of the Standard stock is less than of the Select, so that the Standard stock, if anything, acts better under the weather than the Select.

Rustic stock is of more or less coarse grain but strictly sound and harder than either Standard or Select stock. Rustic stock is used to a considerable extent for country residences and terrace work, hence its name. It is recommended principally for sawed ashlar. When used for molded work the treatment should be bold as it cannot be machined as readily as the other grades.

Variegated stock is an irregular mixture of buff and gray produced from the blocks that are quarried where the buff and gray color-tones adjoin in the quarry. It shows variation in texture as well as color. Variegated stone when cut into building units will exhibit, in these, units of each color-tone and a small percentage of units with both color-tones in one piece. Variegated stone is unusually effective in giving variety to plain surfaces and is a desirable class of material for trim as well as for facing.

There are certain grades of Indiana Oolitic limestone especially adapted for grade courses, steps, buttresses, floor tiling, etc., or any position in the building exposed to abrasion. Some are available in different color-tones and may be identified by the following names: Special Hard Gray and Special Hard Buff Indiana Limestone.

The following are the trade terms by which the different grades of Indiana limestone are commonly known:

Select Buff	Standard Buff	Old Gothic
Select Gray	Standard Gray	Variegated
Indiana Travertine	(both buff and gray)	Rustic

Old Gothic is used largely for rough-sawed random ashlar work, for residences, and for field work in churches, school and college buildings, etc.

The Old Gothic stone is ungraded and is usually furnished in short length blocks. It has a full range of variation with most of the select or fine grain stock removed.

Finishes of Indiana Limestone.—The following finishes are ordinarily used on Indiana limestone: Any finish desired except bush-hammering and other hard stone finishes can be used.

Some of the machine finishes are sand sawed finish, chat or shot-sawed finish, smooth machine finish, wet rubbed finish, machine tooled finishes, carborundum finish and plucked finish. The class of tooling in common practice is understood to cover what is properly termed fluting, that is, concave depressions, four and six parallel, concave grooves to the inch. Convex tooling is sometimes used effectively, but is never applied unless specifically designated. Two bat tooling has been successfully applied (and always vertically) in construction requiring large ashlar facets. Two bat tooling, however, is expensive because it must be superimposed or matched, as wide tooling should not be applied promiscuously, the lines must be continuous from course to course.

It is generally recommended that all molded work be finished smooth. If it is tooled at all, the tooling should run in the direction of the mold and not across it, unless largely increased expense is of no consequence. As to tooled ashlar, some architects contend vertical tooling is preferable, others prefer the horizontal.

Indiana Oolitic limestone will take most hand finishes which under certain conditions are considered preferable to machine finish. Notable examples of this class of work are crandalling and tooth chiselling, but a number of the hand finishes can now be simulated by machine work.

A smooth finish is not commonly furnished other than in the form it comes from the planers. If sand rubbing is desired, it should be specified, and in such event the sand rubbing should be by the wet process or carborundum-and-water rubbed finish. It is contended by many that sand rubbing is the best finish for smoky city atmospheres because a surface so treated offers no lodging place for grime.

Back-Painting Indiana Limestone Not Recommended by Quarrymen and Producers.—Waterproofing of Indiana limestone is not generally recommended by the producers of the stone except in certain types of construction, where the use of suitable waterproofers is advisable.

There are several types of waterproofing materials; those of the colorless type which can be applied to exposed surfaces and the black type made up largely of bituminous material which should be used only on the back of the stone or on the face of the masonry backing or other places where the black is not objectionable.

Some colorless types have the disadvantage of darkening the color-tone of the stone for some time, also at times giving it a greasy appearance. This will in most cases gradually bleach out, leaving the stone with a satisfactory light color. The type is, how-

ever, fairly effective as a waterproofing agent, retaining its effectiveness for many years.

At present external treatments are one of three types: stearates, silicone resins in a solvent and sodium methyl siliconate in an aqueous solution.

Black waterproofing compounds contain bituminous material as their principal base and may generally be divided into three types as follows:

1. Those preparations that consist of mineral asphalt or coal tar which is cut with volatile solvent, such as gasoline, to such a consistency that it may be applied with a brush.

2. Asphalts which are emulsified in water with the aid of some inert emulsifying agent, to a somewhat stiffer consistency than Type 1.

3. The mastic type, comprising those bituminous waterproofing compounds which are of such a consistency that they must be applied with a trowel or similar tool.

Types 1 and 2 have been used quite extensively in the past for back-painting stone, but this procedure is not much used now, due to the fact it did not achieve desired results. One of these types should be applied in all cases where water containing alkali or vegetable matter might otherwise reach the back of Indiana limestone facing.

When limestone is coated on the back and beds with waterproofing applications, the bonding property of the stone is materially impaired and provision must be made to procure sufficient bond either with additional anchorage or bond stones.

In connection with the application of limestone facing to reinforced concrete structures or concrete fire-proofing, it is essential that some form of stain prevention be used. In such instances the dampproof coating should be applied to the face of the concrete members and not to the backs of the stone. A full inch space should be allowed between the back of the stone and finished face of the concrete when detailing this work, while in actual practice it will give an average ¾-inch backing joint.

Contractors should also use the utmost precaution during construction to prevent drippings and wash from the concrete floor construction, during rains, from running down on cut stone or into the backing of the walls below. Carelessness during construction is often the cause of unsightly discoloration that sometimes appears on limestone buildings.

Mortar for Setting and Back-Plastering Indiana Limestone.—Both theory and experience indicate that the most satisfactory results are obtained by setting cut stone facing and masonry

backing in one mortar selected to meet the particular requirement of the building.

The following three types of mortar are recommended for setting limestone. The best type adapted to the particular work should be selected and included.

Non-Staining Cement Mortar.—The cement mortar shall be composed of one (1) part of non-staining cement to three (3) parts of sand with the addition of one-fifth (⅕) part of hydrated lime based on the cement volume.

Non-Staining Cement-Lime Mortar.—Cement-lime mortar shall be composed of one-half (½) part of non-staining cement, one-half (½) part of hydrated lime or quick lime paste and not to exceed three (3) parts of sand.

If quick lime paste is used, first thoroughly mix the quick lime paste and sand and stack to age; the cement shall be added and thoroughly worked into the lime and sand mixture in small batches just prior to use.

Quick lime shall be reduced to a paste by thorough and complete slaking with cold water and screening through mesh screen into a settling box. Lime putty shall stand not less than one week before use.

Sand shall be clean and sharp, free from loam, silt, vegetable matter, salts, and all other injurious substances with grains graded from fine to coarse. Screen through a 6-mesh screen.

Non-Staining Waterproof Cement Mortar.—Recommended for use wherever parging is required or when any of the construction materials, such as water, sand, brick, tile, etc., are known to contain salts which may cause staining or efflorescence; and to walls exposed to excessive amounts of moisture.

Non-staining waterproof cement mortar shall be composed of one (1) part of non-staining waterproof cement to three (3) parts of sand with the addition of one-fifth (⅕) part of hydrated lime based on the cement volume.

Mortar Requirements for Setting Limestone.—For quantity and cost of mortar required for setting limestone, refer to pages 820 and 821.

Weight of Indiana Limestone.—Indiana limestone weighs 200 lbs. per cu. ft. when furnished in rough quarry blocks and 180 lbs. per cu. ft. in scabbled quarry blocks. These figures include the weight of rough excess stone.

Sawed slabs or other squared material weighs 170 lbs. per cu. ft. The weight of the finished cut stone ready to set in the building is figured at 150 lbs. per cu. ft. If there are any large round columns in the job, they may be figured at 140 lbs. per

cu. ft. of stock. The actual net weight of a cu. ft. of dry seasoned stone is 144 lbs.

Freight Rates on Indiana Limestone.—When estimating the freight on Indiana limestone, finished ready for the building, always figure the freight on the entire job on the basis of 150 lbs. per cu. ft. of stone.

The following rates apply from the Bedford district to various parts of the United States and will assist the estimator in figuring delivered prices on this material.

All freight rates are given per 100 lbs. in carload lots:

From Indiana to—	Freight Per 100 Lbs.	Freight Per Cu. Ft.
New York City	$ .89	$1.335
Washington, D. C.	.78	1.17
Chicago, Ill.	.355	.5325
Denver, Colo.	1.31	1.965
San Francisco, Calif.	1.925	2.8875

Average Prices of Indiana Limestone.—Where the cut stone for any job consisting of ashlar, sills, steps, coping, plain machine moldings, etc., is furnished by any of the mills in the Bedford or Indiana limestone district, the price will vary from $5.00 to $8.00 per cu. ft. f.o.b. cars at the mills.

Considerable variation in price is due to the following reasons: Stone consisting of lightweight pieces, such as 4″ or 6″ ashlar, small molded courses, small turned columns, bases, sills, coping, etc., require a comparatively small amount of stone but involves considerable cutting and finishing expense, and even higher costs will prevail.

On other jobs consisting of fairly large stone, 8″ or more thick, large molded pieces, bases, columns, etc., the cubical contents are a deciding factor, and the cu. ft. price of this stone, even for more elaborate work will usually average less in cost than the lighter stone described above.

Jobs containing many large pieces of stone will take the minimum price.

To the above prices it will be necessary to add freight or trucking from the Bedford district to destination on the basis of 150 lbs. per cu. ft.

Always remember that the cube of the largest dimensions must always be used when computing the quantity, cost and weights of stone of any kind.

Current Prices on Indiana Limestone

The following prices are for rough and sawed quarry blocks, f. o. b. cars in Indiana, and will undoubtedly assist the estimator in preparing detailed estimates on the various classes of work, and especially where different grades of stone are specified. Prices are corrected to date of publication and are given per cu. ft. of stone.

	Blocks Rough	Scabbled Blocks	Slabs Sawed 2 Sides	Strips Sawed 4 Sides
Statuary Buff	$3.50	$3.95	$4.55	$4.95
Select Buff	2.20	2.65	3.00	3.70
Standard Buff	1.95	2.40	2.75	3.40
Rustic Buff	1.15	1.60	1.95	2.65
Select Gray	1.70	2.15	2.50	3.40
Standard Gray	1.45	1.90	2.25	3.05
Rustic Gray	.90	1.35	1.70	2.30
Variegated	1.15	1.60	1.95	2.65
Old Gothic	.55	1.00	1.35	2.15

The foregoing prices are per cu. ft. of stone and are on promiscuous sizes in lengths from 5′-6″ to 12 ft., general average around 8′-0″, and are for carload lots, f.o.b. cars at quarries or mills, Bedford District, Ind.

Stone sawed four sides ordered in quantities of less than 50 cu. ft., add at least 20 cts. per cu. ft. (dependent upon quantity) to the above prices.

There is an extra charge for slabs sawed 2 sides and strips sawed 4 sides gotten out to a thickness of less than 4 inches.

Preparing Detailed Estimates of Indiana Limestone

If the estimator desires to prepare detailed estimates on the cost of all Indiana limestone required, it will be necessary to take the price of the rough or scabbled quarry blocks, sawed slabs or sawed strips as given in the foregoing prices covering the various classes of material.

It will also be necessary to compute the various labor and machine operations required to transform the rough stock into finished stone, ready to set in the building. This will require considerable more time than averaging, but will result in more accurate costs.

The prices on the various labor and machine operations given on the following pages approximate the scale of wages prevailing in the Indiana limestone district at the present time.

Stonecutters	$3.30 per hour
Planermen	3.05 per hour
Diamond Jointing Sawyers	2.50 per hour
Carvers	3.60 per hour
Planermen on circular work	3.15 per hour
Headermen and Shapermen	3.15 per hour

Prices on Standard Items of Indiana Limestone

All of the following prices are based on Variegated Indiana Limestone, f.o.b. mills, Bedford District, Indiana.

	Price per Cu. Ft.
Item No. 1. Door Sills	$3.25
Item No. 2. Sill Stock	
S-4-S Long Lengths 0′-2¼″ thick	3.50
S-4-S Long Lengths 0′-3″ thick	3.20
S-4-S Long Lengths 0′-4″ or over thick	3.00
S-6-S	
0′-2¼″ thick	3.65
0′-3″ thick	3.50
0′-4″ or over thick	3.25
Item No. 3. Bull Nose Step	4.55
Item No. 4. Bull Nose Step	4.30
Item No. 5. Bull Nose Sill	4.80

Cutting Beds and Joints.—When cutting beds and joints the cost will vary with the size of the stone. The smaller the stone the higher the price per cu. ft. and the larger the stone the less the price per cu. ft. For instance, a piece of ashlar 8″ thick contains twice as many cu. ft of stone as a piece 4″ thick, while the cost of cutting the joints will not be much more on the larger piece than on the smaller.

Where the joints are cut by hand, the cost will vary from $0.80 to $1.00 per cu. ft., depending upon the conditions stated above.

On the second sawing, where sawed slabs are used and it is necessary to run them through the saw the second time for top and bottom beds, it will cost 80 cts. per cu. ft. for this work.

Where the jointing is done on the saw, figure 65 cts. per cu. ft. for cutting joints.

Smooth or Planer Finish.—When Indiana limestone is wanted with a smooth finish as it comes from the planer, the cost will vary from 45 to 50 cts. per sq. ft. of surface planed.

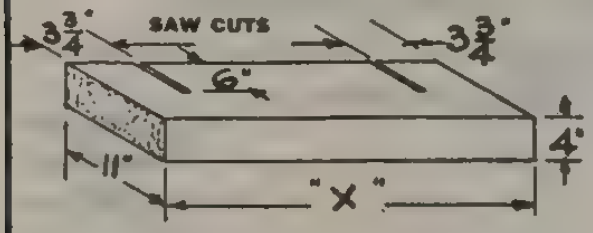
The slabs are usually furnished sawed to the correct thickness

and then the stone is run through the planer to remove th saw marks, which is not a very expensive process on straigl work.

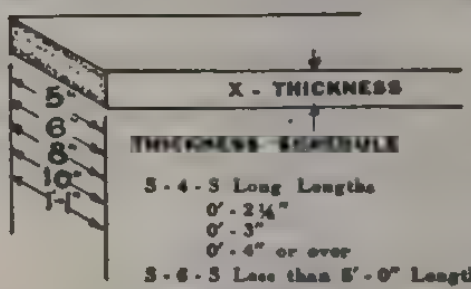
STANDARD ITEMS

ITEM NO. 1 - DOOR SILL

X = 3'-3", 3'-5", 3'-9" & 3'-10"



ITEM NO. 2 - SILL STOCK

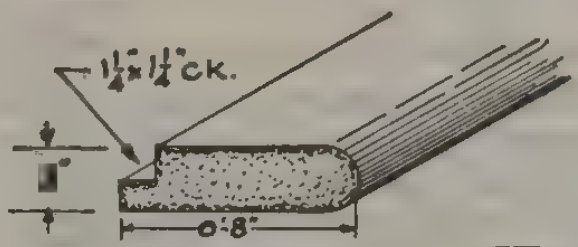


THICKNESS SCHEDULE

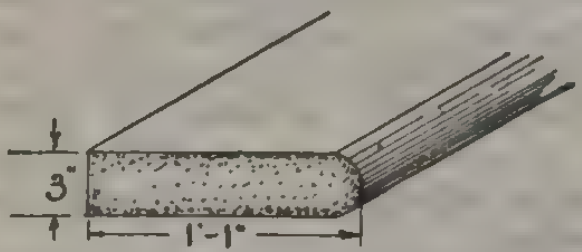
3 - 4 - 5 Long Lengths
0' - 2¼"
0' - 3"
0' - 4" or over

3 - 6 - 5 Less than 5' - 0" Lengths
0' - 2¼"
0' - 3"
0' - 4" or over

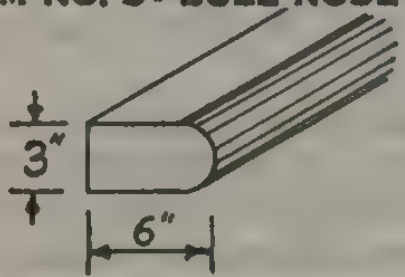
ITEM NO. 3 - BULL NOSE STEP



ITEM NO. 4 - BULL NOSE STEP



ITEM NO. 5 - BULL NOSE SILL



NOTE - ALL ITEMS BASED ON VARIEGATED INDIANA LIMESTONE.
ALL PRICES F. O. B. COMPANY MILLS, BEDFORD, INDIANA.

On the cheaper classes of work, and on some of the higher grade work where a sawed finish is desired, the sawed slabs

are jointed and the stone is sent to the building without having been run through the planer. Work of this class is a little cheaper than stone having a first class finish.

Tooled Finish.—If the stone has a tooled finish, having 4, 6, 8 or 10 bats to the inch, the cost of horizontal tooling on plain surfaces will cost 45 to 50 cts. per sq. ft. (not cu. ft.) of surface tooled, or about the same as planer finish.

Hand vertical tooling in connection with machine molded work will add 50 to 55 cts. per sq. ft. of surface finished.

Cross or vertical tooling on curved surfaces will add $1.00 per sq. ft. of surface finished.

Two bat tooling, which is always used vertically, can be done for almost the same cost as given above if it is not made to register. This tooling, however, usually has to be made to register and for that reason is generally more costly than 4, 6, 8 or 10 bat work.

Sand Rubbed Finish.—If the stone is to have a sand rubbed finish, making it necessary to rub the surface with sand and water, add 45 to 50 cts. per sq. ft. for all surface to be rubbed.

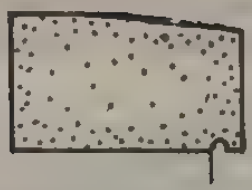
Rustication.—If the stone is to be furnished with rustication or a "rabbet" along the edges of the stone, the cost will vary according to the depth of the rabbet. This is all planer work, so the width of the rabbet does not make as much difference as the depth to which it must be cut.

The following will prove a fair average of the cost of rustication:

Depth in inches	Price Per Lin. Ft.	Depth in inches	Price Per Lin. Ft.
½	$0.46	2	$0.77
1	.54	2½	.90
1½	.65	3	1.04

The prices on the previous page are for plain rabbets. The cost of this work will vary considerably according to the manner in which it is detailed.

Plain Door and Window Sills.—Stone for plain door and window sills, without lugs, thresholds and waterbars is usually furnished from the quarries, sawed four sides, so that it is only necessary to joint same and it is ready to place in the building. Stone of this class and finish is used extensively in many of the cheaper buildings, such as factory buildings, warehouses, apartments, residences, etc.



Plain Window Sills.

Lug Window Sills.

This stone will usually take the minimum price as there practically no planer work on it (the saw marks may be see on the face of the stone) and as it comes from the quarrie sawed to the proper dimensions, all that is necessary at th yard is the jointing and a slight drip underneath.

The basis for computing sills of this kind is as follows:

	Contents	Rate	Tot
Sawed strip, 0'-4"x0'-7"x4'-0".....	.78 cu. ft.	$3.40	$2.6
Cutting end joints.....	.78 cu. ft.	1.00	.7
Cutting drip.....	4 lin. ft.	.22	.8
Overhead expense and profit.....		25%	1.0
Cost 0.78 cu. ft.....			$5.3
Cost per cu. ft.....			6.9
Cost per lin. ft.....			1.3

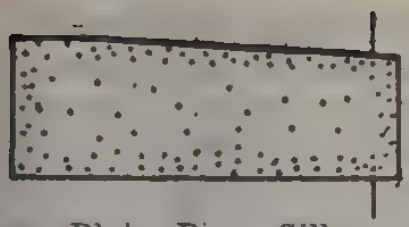
To compute the cost of a plain stone door sill, withou thresholds or drips, the following method should be used:

	Contents	Rate	Tot
Sawed strip, 0'-5"x1'-2"x3'-8".....	1.75 cu. ft.	$3.40	$5.9
Cutting end joints.....	1.75 cu. ft.	.90	1.5
Overhead expense and profit....		25%	1.8
Cost 1.75 cu. ft.....			$9.4
Cost per cu. ft.....			5.3
Cost per lin. ft.....			2.5

The above prices are for stone with sawed finish only. I a smooth, planer finish is wanted, add extra for planer work.

Lug Window Sills.—If stone window sills are to have a plane finish, lugs, water bar, and drip underneath, a window sil 0'-8"x0'-5"x4'-0" should cost as follows:

	Contents	Rate	Tota
Sawed slab, 0'-8"x0'-5"x4'-0".....	1.13 cu. ft.	$2.65	$2.9
Second sawing, face and back.....	1.13 cu. ft.	.80	.9
Cutting end joints.....	1.13 cu. ft.	1.00	1.1
Planer finish on face.....	2 sq. ft.	.50	1.0
Cutting lugs, water bar, and drip..	4 lin. ft.	1.00	4.0
Overhead expense and profit.....		25%	2.5
Cost 1.13 cu. ft.....			$12.5
Cost per cu. ft.....			11.0
Cost per lin. ft.....			3.1



Plain Door Sills.

Door Sills with Threshold.

Stone Door Sills Having Thresholds.—If stone door sills are to have a planer finish, formed threshold and drip underneath, a 1′-3″x0′-7″x4′-0″ door sill should cost as follows:

	Contents	Rate	Total
Sawed slab, 1′-3″x0′-7″x4′-0″	3 cu. ft.	$2.65	$7.95
Second sawing, face and back	3 cu. ft.	.80	2.40
Cutting end joints	3 cu. ft.	.90	2.70
Planer finish on face	2.5 sq. ft.	.50	1.25
Cutting threshold, drip, etc.	4 lin. ft.	1.00	4.00
Overhead expense and profit		25%	4.58
Cost 3 cu. ft.			$22.88
Cost per cu. ft.			7.63
Cost per lin. ft.			5.72

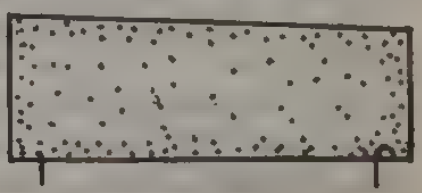
Plain Stone Coping.—Where stone coping is used, having only a slight drip on one side, plain sawed stock is ordinarily used, without planer finish. This stock is usually furnished by the quarry sawed either two sides or four sides, making it only necessary to joint same before sending to the job.

A piece of stone coping 1′-3″x0′-5″x5′-0″ should cost as follows:

	Contents	Rate	Total
Sawed slab, 1′-3″x0′-5″x5′-0″	2.6 cu. ft.	$2.65	$ 6.89
Second sawing, 2 sides	2.6 cu. ft.	.80	2.08
Cutting end joints	2.6 cu. ft.	.90	2.34
Cutting drip	5 lin. ft.	.22	1.10
Overhead expense and profit		25%	3.10
Cost 2.6 cu. ft.			$15.51
Cost per cu. ft.			5.97
Cost per lin. ft.			3.10

Stone Coping with Wash and Drip.—If the stone coping is to have a planer finish with three square sides and the top slant-

Plain Wall Coping.



Wall Coping with Wash and Drip.

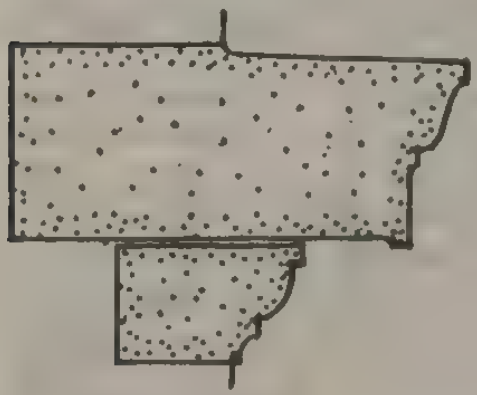
ing forming a wash toward one side and a drip underneath, a piece of stone coping 1'-3"x0'-5"x5'-0" should cost as follows:

	Contents	Rate	Total
Sawed slab, 1'-3"x0'-5"x5'-0"	2.6 cu. ft.	$2.65	$6.89
Second sawing, 2 sides	2.6 cu. ft.	.80	2.08
Cutting end joints	2.6 cu. ft.	.90	2.34
Planer finish on sides	5 sq. ft.	.50	2.50
Planer finish and wash on top	6.25 sq. ft.	.50	3.13
Drip	5 lin. ft.	.22	1.10
Overhead expense and profit		25%	4.51
Cost 2.6 cu. ft.			$22.55
Cost per cu. ft.			8.67
Cost per lin. ft.			4.51

Rounded Edges on Stone.—Add about 22 cts. per lin. ft. for stone with edges slightly rounded.

Stone Moldings.—The cost of stone moldings will vary greatly according to the size of the stone, the type of mold, breaks, heads, jointing, etc. The two kinds of moldings most commonly used are plain or Classic moldings and Gothic moldings.

When cutting stone moldings on a planer, the smaller the piece of stone the higher the price per cu. ft., on account of the additional labor involved and the small amount of stone required.



Plain Moldings.

Gothic Moldings.

Tools for cutting moldings vary from 3" to 8" wide, so when the moldings are over 8" in width, it is necessary to run them through the planer a second time.

The moldings that are the cheapest to run are similar to the illustration of plain moldings, where a large amount of stone is required on which no special work is necessary. On work of this kind the actual cost of running the moldings averages only slightly more than the average cu. ft. prices given on the previous pages.

When estimating plain moldings, take the largest dimensions of the stone to obtain the cubical contents and figure at the average price as given on the previous pages, as this will cover most jobs where the molded courses do not form too large a proportion of the total stone in the job.

Gothic Moldings.—Gothic moldings are much more expensive than plain or Classic moldings, as in almost every instance it is necessary to run the stone through the planer twice or perform a certain amount of hand labor in connection with same. Gothic moldings cost at least twice as much to run as plain or Classic moldings. The cutting of heads for Gothic moldings will run much higher than plain moldings, or from $2.50 to $10.00 each, depending upon the size and character of the molding.

When entire jobs consist of elaborate Gothic stone, they frequently will run from $7.50 to $20.00 per cu. ft. On work of this kind it is advisable to obtain figures from a reputable concern covering the stone delivered ready to set.

Turned Balusters.—When estimating the cost of slender turned stone balusters, the item of breakage requires consideration, as there is a large percentage of waste in this class of work. The balusters usually break after they are about 75 percent completed.

On plain turned balusters, without hand work, take the cubical contents of the largest dimensions, and price same at about 20 cts. per cu. ft. more than the average prices given on the previous pages.

After the contents have been estimated by the cu. ft., the following allowance should be made to take care of the extra labor involved in turning each baluster on the lathe. This applies to jobs having about 50 balusters. Where there are more the turning cost will be reduced and where there are fewer, the cost will be increased.

Size of Balusters	Add Extra Each Baluster
For plain turned balusters up to 5"x5"-20" in size	$ 8.00
For plain turned balusters up to 6"x6"-24" in size	9.00
For plain turned balusters up to 7"x7"-24" in size	9.50
For plain turned balusters up to 8"x8"-24" in size	10.00
For plain turned balusters up to 9"x9"-24" in size	12.00
For plain turned balusters up to 10"x10"-24" in size	15.00

Round Stone Columns.—When estimating the cost of plain turned columns, the cubical contents should be obtained by taking the cube of the largest dimension (measured square) and price as follows:

Obtain the cu. ft. cost of the grade of stock to be used whether select buff, standard buff, select gray, etc., and add seven times the cu. ft. cost of the rough quarry blocks. This will give the cu. ft. price at which the columns should be estimated. For instance, a turned column 3'-0" in diameter and 36'-0" long would contain 3'x3'x36' or 324 cu. ft. of stone. Select buff is worth $2.20 per cu. ft. in rough blocks. Multiply $2.20×7 gives $15.40 per cu. ft. 324 cu. ft. @ $15.40 equals $4,989.60, the cost of one column.

A stone column 38'-0" long is the usual limit of present day machine capacity, so when the column shaft is over 36'-0" long it is best to get them out in three sections.

Fluted Stone Columns.—Fluted stone columns should be figured on the same basis as plain turned columns described above. After the cost of the plain column has been obtained the cost of the flutes should be estimated at 50 cts. per lin. ft. of each flute in the column.

Cartage on Cut Stone.—If it is necessary to haul the cut stone from the mill or from the cars to the building site, it is worth 50 to 55 cts. per cu. ft. for hauling, where reasonable care is exercised in loading and unloading the stone. This applies to jobs within a reasonable distance of the yard or cars.

Cutting Raised Letters in Indiana Limestone.—The cost of cutting raised letters in Indiana limestone will vary according to the size and style of the letters.

On average work, a stone carver should cut one 6" letter an hr. at the following labor cost per letter:

	Hours	Rate	Total	Rate	Total
Stone carver	1	$.....	$.....	$7.10	$7.10

If the letters are 12" high, it will require about 1½ hrs. time per letter, at the following labor cost per letter:

	Hours	Rate	Total	Rate	Total
Stone carver	1.5	$.....	$.....	$7.10	$10.65

Cutting Sunk Letters in Indiana Limestone.—The cost of cutting sunk letters is considerably less than raised ones.

When cutting letters up to 6" high, a cutter should cut one letter in about 20 minutes at the following labor cost per letter:

	Hours	Rate	Total	Rate	Total
Stone cutter	.33	$.....	$.....	$7.10	$2.37

If the letters are 12" high, a cutter will cut 1 letter an hr. at the following labor cost per letter:

	Hours	Rate	Total	Rate	Total
Stone cutter	1	$.....	$.....	$7.10	$7.10

ILCO Stone*

Ilco Stone is supplied in a choice of three finishes: Splitstone, Shot-Sawn and Sand-Sawn. All three have been extensively used in homes, apartment houses, churches, motels, colleges, institutions and numerous types of commercial structures.

Splitstone is split by modern machinery giving a splitface finish; Shot-Sawn is obtained by using steel shot under the saws to give rippled finish and Sand-Sawn is obtained by using sand with the saws to obtain a smoother finish.

Both Split and Sawed Stone is produced and shipped in lots of three heights; namely 2¼", 5" and 7¾". 10½" heights are furnished if desired. The lengths are promiscuous ranging from 1'-0" to a maximum of 6'-0" with sawed beds and almost 100 percent jointed.

Splitstone is around 3½" thick and one ton provides approximately fifty (50) sq. ft. of wall coverage. Sawed finishes are available in either 3 inch or 4 inch thicknesses. One ton of 3 inch will provide approximately fifty-five (55) sq. ft. of wall coverage. One ton of 4 inch will provide approximately forty (40) sq. ft. of wall coverage. Where bond stone is required it is supplied at no extra tonnage cost. The stone is unselected for color and texture with various shades of buff and gray.

Splitstone is also available in a 3" course height with a 3" bed. Because of the 3" bed and because there is no loss due to fitting a pattern coverage is about 60 sq. feet per ton.

To get the number of tons of Ilco Stone required for a building, take the sq. footage less openings and divide by 40, 45 or 50 (depending on finish desired).

The average random wall pattern for either finish requires approximate quantities of the various heights as follows: 2¼" heights, 15%; 5" heights, 40%; 7¾" heights, 45% and 10½" heights if desired.

The following prices apply f.o.b. mills, Bedford, Indiana:

Splitstone	$31.00 per net ton
Splitstone 3x3	33.00 per net ton
Shot-Sawn	41.00 per net ton
Sand-Sawn	41.00 per net ton

A minimum truckload freight charge is based on 12 tons and 16 tons.

A minimum rail shipment is based on 18 and 30 tons.

The cost of stone in the wall depends on the location as the

*Indiana Limestone Co., Bedford, Ind.

freight is based on mileage, also the hourly wage scale varies in different localities.

The Indiana Limestone Company, Inc., will be glad to furnish the freight rates on request to any point either by truck or rail.

Jointing is a simple operation and the only tools really necessary are a square, a carpenter's hand saw and a mason's hammer. A groove about ¼" deep is sawed in the face of the stone and then a sharp tap on the back with the hammer breaks the stone squarely in line with the cut on the face. The strip can be broken to length easier and somewhat faster by using a portable electric carborundum saw for grooving the stone. In breaking the stone for the wall there is some waste, which should not exceed 5%.

Labor Laying Ilco Stone.—When laying Ilco stone in veneer work, a mason should set 90 to 110 sq. ft. of 4" stone per 8-hr. day, but if backed up with masonry the square foot costs will be about 10 to 15 percent higher.

Cost of 100 Sq. Ft. of Ilco Stone Ashlar Used as a Veneer Over Wood Frame Buildings

	Hours	Rate	Total	Rate	Total
2.5 tons Ilco stone		$.....	$.....	$33.00	$ 82.50
Freight and trucking 5,000 lbs.				.72	36.00
7 cu. ft. mortar				.88	6.16
Mason cut and fit	8	.....	.....	7.10	56.80
Mason setting	8	.....	.....	7.10	56.80
Labor	8			5.00	40.00
Cost per 100 sq. ft.	24		$.....		$278.26
Cost per sq. ft.					2.78
Cost per ton			.....		111.30

Cost of 100 Sq. Ft. of Ilco Stone Ashlar Used in Churches, Fine Residences, Etc., Having Masonry Backing

	Hours	Rate	Total	Rate	Total
3 tons Ilco stone		$.....	$.....	$33.00	$ 99.00
Freight and trucking 6,000 lbs.				.72	43.20
10 cu. ft. mortar		.....	.....	.88	8.80
Mason cut and fit	9	.....	.....	7.10	63.90
Mason setting	9	.....	.....	7.10	63.90
Labor	11	.....	.....	5.00	55.00
Cost per 100 sq. ft.	29		$.....		$333.80
Cost per sq. ft.					3.34
Cost per ton			.....		111.27

Ashtone* Split Faced Ashlar.—Ashtone is a split-faced Indiana Limestone used for random ashlar walls and is readily adaptable for residential, church and small building construction. This stone is furnished with a split face and back with sawed surfaces for top and bottom beds. The bed thickness of the stone is 3½" except for masonry construction where the desired percentage of 8" bed stone is furnished to bond with the masonry backing.

This stone is produced in course heights of brick multiples, ie., 2¼", 5", 7¾" and 10½" and in unjointed strips in lengths ranging from 2'-0" to 7'-0" and is broken to length at the building site.

Inasmuch as both the face and back are split-faced finish the builder can vary the convex and concave surfaces to suit his desires. The top and bottom beds are sawed finish and as the stone is furnished in multiples of brick course heights, it can be easily set and the jointing is a simple operation. A square,

A House Constructed of Ashtone* Split-Faced Ashlar

*Bloomington Limestone Corp., Bloomington, Ind.

a carpenter's hand saw and a mason's hammer are the only tools necessary. A groove about ¼" deep is sawed in the face of the stone and then a sharp tap on the back with the hammer breaks the stone squarely in line with the cut on the face. The strips can be broken to length easier and somewhat faster by using a portable electric carborundum saw for grooving the stone.

This stone is sold by the ton of 2,000 lbs. and when laid with a ½-in. mortar joint, one ton should be sufficient for about 45 sq. ft. of wall surface.

Prices on the unjointed stone are as follows:

Grade of Stone	Price per Ton**
Old Gothic	$30.00

Cost of 100 Sq. Ft. of Ashtone* Split Faced Ashlar In Straight Walls, Used as a Veneer Over Wood Framing and Sheathing

	Hours	Rate	Total	Rate	Total
2.2 tons split faced ashlar		$.....	$.....	$30.00	$ 66.00
Freight and trucking, 4,400 lbs.		.....	.....	.72	31.68
7 cu. ft. mortar.....		.....	.....	.88	6.16
Mason cut and fit.....	8	.....	.....	7.10	56.80
Mason setting	8	.....	.....	7.10	56.80
Labor	8	.....	.....	5.00	40.00
Cost per 100 sq. ft.....	24		$.....		$257.44
Cost per sq. ft.			.....		2.57
Cost per ton			.....		117.02

Cost of 100 Sq. Ft. of Ashtone* Split Faced Ashlar Used In Churches, Libraries, Residences, Etc., Having Masonry Backing

	Hours	Rate	Total	Rate	Total
2.5 tons split faced ashlar..		$.....	$.....	$30.00	$ 75.00
Freight and cartage, 5,000 lbs.		.....	.....	.72	36.00
10 cu. ft. mortar		.....	.....	.88	8.80
Mason cut and fit.....	9	.....	.....	7.10	63.90
Mason setting	9	.....	.....	7.10	63.90
Labor	11	.....	.....	5.00	55.00
Cost per 100 sq. ft.....	29		$.....		$302.60
Cost per sq. ft.			.....		3.03
Cost per ton			.....		121.04

*Bloomington Limestone Corp., Bloomington, Ind.
**Prices f.o.b. cars, Bloomington, Ind.

NATURAL GRANITE

Granite is an igneous stone. It is extremely hard and weighs 160 lbs. per cu. ft., or 15 to 20 percent more than cut stone. It is one of the most durable materials available for construction but, because of the high costs of quarrying, fabrication, shipping, handling and setting, considerable time and care must be taken in planning the job and estimating in order to make the best use of the material.

Granite is usually thought of as a facing material for the lower stories of buildings where durability is paramount. However, several new tall buildings, such as the 38-story CBS Building in New York City and the Canadian National Bank in Montreal, have been faced with granite full height. It is also now popular as a sidewalk material for the large plazas around new skyscrapers such as the John Hancock Center in Chicago.

Uses of Granite.—Granite can be classified into three basic groups, each having its own design and specification requirements.

Standard building granite is used structurally either self-supporting or as bonded masonry. Granite has a compressive strength of 20,000 p.s.i. and is well suited for bearing walls.

Granite veneer is a facing used for decoration or protection, rather than for its structural value and is applied to masonry backup with stainless steel anchors engineered for the job. Veneers will vary from $1\frac{1}{8}$" in thickness up to 8", the majority being in the 2" to 4" range. Also being developed today are precast "curtain wall" panels using granite facing. These are supported from the building framing rather than from the backup and present different construction problems altogether.

Masonry granite is granite used as an integral part of a masonry wall in which one of the more rugged finishes are used, such as in churches, rambling residences, bridge abutments, and the like.

Granite Finishes.—Granite is available in a wide range of finishes from split faced to mirror finished slabs.

Polished face is a mirror gloss; honed face, a dull gloss; and fine rubbed, a smooth finish with no gloss. Allowable tolerance for these three types is $\frac{3}{64}$".

Next are the rubbed finishes. Sand finish is slightly pebbled with a tolerance of $\frac{1}{10}$"; spot finish has circular markings with an indefinite pattern and $\frac{3}{32}$" surface tolerance.

Hammered surfaced granite comes in three grades: fine or 8-cut with parallel markings not over $\frac{3}{32}$"; medium or 6-cut with parallel markings not over $\frac{1}{8}$"; and coarse with parallel markings

not over 7/32". Tolerances are limited to 3/32" for the first two, 1/8" for the third. These are corrugated finishes which become smoother near arris lines, that is, near the intersections of two dressed faces.

Sawn faces may be had with vertical scorings (V.S.M.), horizontal scorings (H.S.M.), or circular scorings (R.S.M.). The first two are produced by gang saws, the second, by rotary or circular saws. Tolerance is 1/8" with scorings 3/32" deep.

Thermal finishes are produced by flame texturing a sawn surface with torches to flake granite to a dull, uniform, regular rough surface of coarse texture. It is popular for large paving blocks. Tolerance is 1/8".

Jet honing is produced by honing previously cut surfaces with a jet of water and compressed air fed with tiny glass spheres under pressure. Tolerance is 1/8".

Shop Drawings.—All granite veneer work should be cut and set in accordance with approved shop drawings. These should show the bedding, bonding, jointing and anchoring details. Each stone is dimensioned and given a setting number. The producer will not cut the granite until all details and dimensions are agreed upon. As jointing in veneer granite work is generally 1/4", extremely accurate measurements are required. Also, the contractor must plan ahead and have cutouts and holes required for lifting large slabs (called Lewis holes) as well as cutouts for posts, door checks, electrical fixtures, etc., as may be required for the work of other trades.

Holes for anchorage are also cut by the contractor furnishing the granite. There should be 2 anchors for slabs up to 2 sq. ft., 3 for slabs from 2 to 4 sq. ft., 4 for slabs to 12 sq. ft., and 6 for slabs to 20 sq. ft.

Color Selection.—Granite is a natural material and colors are varied, often two to three per material. Color may be selected from samples or specified by quarry. As shipping costs can be a major factor in a material as heavy as granite, local quarries with similar colors can effect major savings.

However, when the architect specifies a color by quarry, any substitution should be made only with his written approval or as an alternate, lest the contractor be held for the difference in shipping costs.

Granites with feldspar produce the red, pink, brown, buff, grey and off-white varieties; those with horn blende or mica produce the dark greens and blacks.

Graining as well as color is a consideration; a uniformity of texture, whether fine, medium or coarse, being desirable.

The National Building Granite Quarries Assoc., Inc., 1426 G St., N.W., Washington, D.C., publishes a list of granite suppliers with colors and graining available from each. Canada and Sweden are also major sources.

Job Conditions.—The granite contractor must check job conditions carefully. His product is expensive: defective or damaged work is almost always refused, and replacements can cause costly job delays.

Carefully unpack and inspect all material to assure it matches samples, is cut to dimensions of shop drawings and tolerances of specifications, and to check for shipping damages.

Carefully store all granite on non-staining platforms at least 4" off the ground. Plug all holes during freezing weather.

Check hoist and scaffolding conditions if they are involved. Dirty hoists and scaffolding can stain granite.

Check backup construction. Backup must be laid to a true line. Concrete and masonry backup should be coated with asphalt. If this is not in other contracts, the granite contractor should provide for it.

If work is to continue alongside or above granite after it is set, add an allowance for protection of exposed surfaces.

Material Cost of Granite.—As discussed above, several factors determine the price of granite, including color, graining and transportation to the site.

The lower priced polished veneers will include the solid blacks and mottled greys. These will run around $7.00 to $8.00 per sq. ft. in 2" to 3" thicknesses. The variegated reds, pinks, and bluish and greenish blacks will cost $9.00 to $10.00 per sq. ft. Sawn finish will run in the $5.00 to $8.00 range, and thermal finish in the $6.00 to $9.00 range.

Random ashlar granites are considerably cheaper, running from $2.00 to $5.00 in 4" thicknesses.. This is also often priced as so much per cu. ft., the range being $6.00 to $15.00.

Dressed granite, machine cut in structural thicknesses, will run $12.50 to $40.00 a cu. ft. depending upon the number of openings, washes and corners. Hand cut granite, as one might find on a mausoleum, can run to $100.00 or more a sq. ft.

Hand cutting, except on the most elaborate work, has been replaced by precision machines. Even surface carving and lettering is done today by sandblasting. Carved letters 6" to 10" high will cost around $15.00 per letter if cut into the granite, $25.00 if raised from the granite.

Cutting of granite into shapes other than square blocks adds quickly to the cost. One source suggests that if a simple square step, which might run $12.50 per cu. ft., were to have a wash or ⅛" slope on the top surface, the cost would increase 23%; a wash on two surfaces, 30%; a wash on two surfaces plus a drip, 42%; and an ogee molding plus a drip, 55%.

Labor Setting Granite Veneer.—One mason and one helper should set from 30 to 40 sq. ft. of veneer per day, polished work with ¼" joints taking more time than straight sawn work. Column enclosures can be figured at around 35 sq. ft. per day. Straight run work with no openings and no hoisting involved can be figured at 50 sq. ft. per day.

The above figures are based on one mason and one helper. On large jobs this ratio may be cut down with 3 laborers serving 4 masons providing scaffolding is arranged so men can move from position to position. In addition, hoisting costs may have to be added.

On a low-rise building, the square foot labor cost for 100 sq. ft. of polished granite veneer would be figured as follows:

	Hours	Rate	Total	Rate	Total
1 mason	20	$.....	$.....	$7.10	$142.00
1 helper	20	.....	.....	5.20	104.00
Cost per 100 sq. ft.	40		$.....		$246.00
Cost per sq. ft.					$ 2.46

Work involving special trim at openings, copings and moldings would require more time:

	Hours	Rate	Total	Rate	Total
1 mason	26.5	$.....	$.....	$7.10	$188.15
1 helper	26.5	.....	.....	5.20	137.80
Cost per 100 sq. ft.	53		$.....		$325.95
Cost per sq. ft.					$ 3.26

Artificial Granite.—Cast granite is manufactured in slabs 1½" to 2½" thick as a less expensive substitute for the natural material. It is not as durable and will not take or hold quite the high polish of the true stone. Still, it has been popular on remodeling and store front work. It is set and handled on the job like true granite.

The material costs less than half, or in the $3.50 to $5.00 range. One mason and one helper should set 50 to 60 sq. ft. per day.

Sawed Bed Rock Face Granite Ashlar*

Sawed bed granite ashlar is used for broken or coursed ashlar as a veneer in the construction of houses, apartments, churches, schools, and other similar construction. Many pleasing patterns can be obtained by suitable selection of rises and lengths.

Sawed bed ashlar is furnished in widths of 3½" and multiples of brick rises, or 2¼", 5", 7¾", 10½" and 13¼". Rises of 3¼" and 7¼" with ¾" mortar joints make a very practical pattern for residential construction.

The material can be shipped in random length sticks and knapped into desired lengths by mason on the job or shipped in jointed lengths, ready to set. Usually contractors like to have about two-thirds of the material finished and the remaining one-third in random lengths for use in fitting at corners and around windows and doors.

Present prices at the quarry range from $1.14 per sq. ft. of wall area for predominantly low rises to 90 cts. per sq. ft. for predominantly high rises.

The average freight east of the Mississippi River is about 18 to 45 cts. per sq. ft. of wall area.

Sawed bed rock face ashlar is also very practical for sills, lintels, steps and coping on granite or brick houses. The following are approximate costs at quarry.

4"x8" jointed lintels	$1.50 per lin. ft.
4"x5" jointed sills	1.25 per lin. ft.
13"x6" jointed steps	2.50 per lin. ft.
12"x5" jointed coping	2.50 per lin. ft.

Labor Setting Granite Ashlar.—The labor cost of setting granite ashlar will vary considerably, depending upon type of wall, height of rises and the skill of the mason. Being thin, sawed bed ashlar is light in weight and easy to handle and when furnished finished or semi-finished, a mason should set 45 to 55 sq. ft. of wall consisting predominantly of low rises per 8-hr. day, and up to 70 sq. ft. of wall, where the ashlar consists principally of high rises.

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*North Carolina Granite Corp., Mount Airy, N. C.

Cost of 100 Sq. Ft. of Sawed Bed Rock Face Ashlar Consisting Principally of Low Rises

	Hours	Rate	Total	Rate	Total
105 sq. ft. granite ashlar		$.....	$.....	$3.00	$315.00
Freight and trucking		.....	.....	.45	47.25*
8 cu. ft. cement mortar..		.....	.....	.88	7.04
Mason cut and fit.....	16	.....	.....	7.10	113.60
Mason setting	16	.....	.....	7.10	113.60
Helper	24	.....	.....	5.00	120.00
Cost per 100 sq. ft.....	56		$.....		$716.49
Cost per sq. ft.....			.....		7.16

Cost of 100 Sq. Ft. of Sawed Bed Ashlar Consisting Principally of High Rises

	Hours	Rate	Total	Rate	Total
105 sq. ft. granite ashlar..		$.....	$.....	$2.75	$288.75
Freight and trucking		.....	.....	.45	47.25*
6 cu. ft. cement mortar..		.....	.....	.88	5.28
Mason cut and fit.....	11.5	.....	.....	7.10	81.65
Mason setting	11.5	.....	.....	7.10	81.65
Helper	24.0	.....	.....	5.00	120.00
Cost per 100 sq. ft.....	47.0		$.....		$624.58
Cost per sq. ft.....			.....		6.25

*Varies according to distance from quarry.

A Residence Constructed of Sawed Bed Rock Face Granite Ashlar

MO-SAI* PRECAST FACING AND CURTAIN WALL

Mo-Sai is a thin, precast, reinforced architectural concrete facing and curtain wall unit. Structural sections are produced, reinforced or prestressed, as required. The product has an exposed aggregate surface which is mosaic in character. Crushed and graded granites, quartzes, and other vitreous bodies form the aggregate. A pre-determined formula of sized aggregate is assembled and combined with cement in a low water-cement ratio.

Casting of Mo-Sai panels is accomplished under high frequency vibration in rigid molds. Surface texture in the desired quality is attained by techniques developed by Mo-Sai Institute. A finished surface is produced which exposes 85 percent aggregate or more. The remaining surface area is composed of matrix.

Mo-Sai is a lightweight material. The slabs weigh 25 lbs. per sq. ft. in 2 inch thickness, and the tested compressive strength of the slabs is not less than 7,500 lbs. per sq. in. Panels are also produced with lightweight aggregate as a backup. Unit weights and compressive strengths vary from the above. Each panel is reinforced with heavy wire mesh, electrically welded and zinc coated.

From plant to setting on the job, Mo-Sai units are handled by conventional hoisting methods. The anchors or special loops provide a means of attaching hooks for lifting.

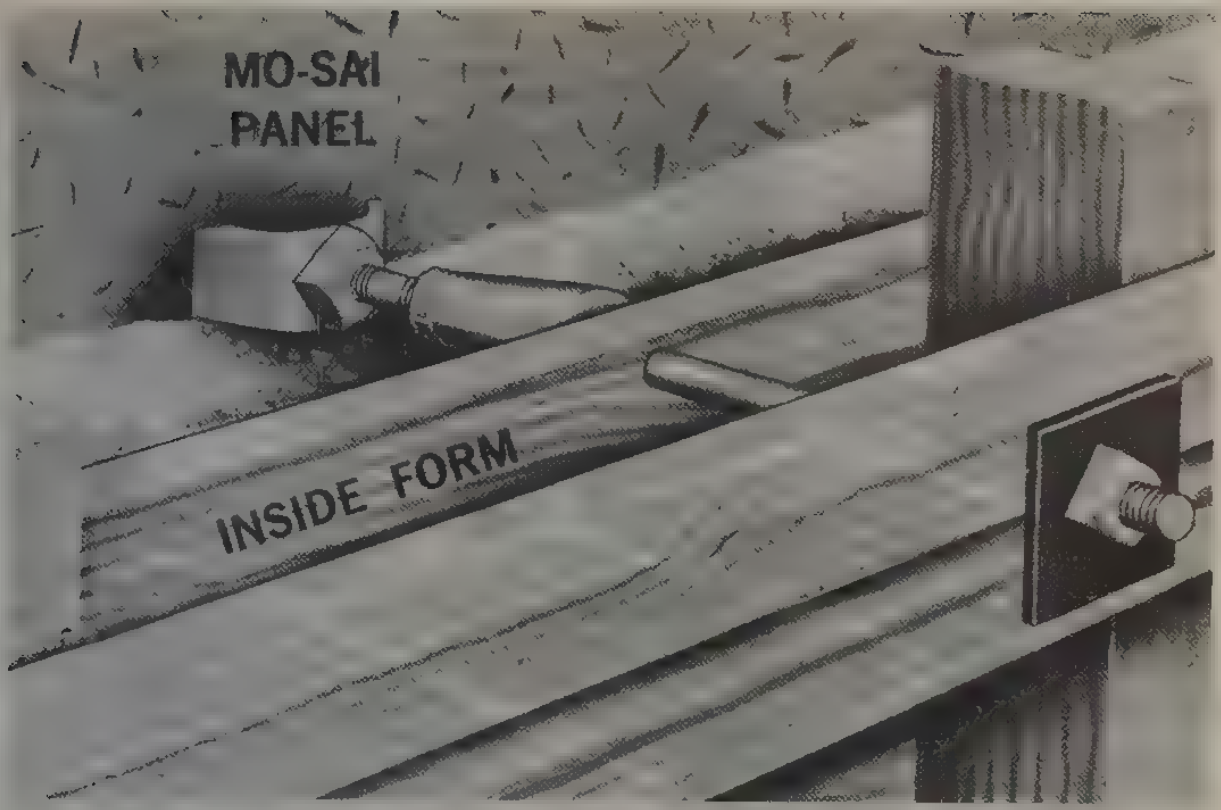
Setting, when used as masonry, should be done through the medium of lead pellets bedded in the setting mortar, after which all joints should be raked out to a depth of ¾". All pointing should be done with an elastic compound or elastomeric sealant applied over a suitable non-staining compressive filler.

When ready for pointing, Mo-Sai slabs shall be cleaned with fiber brushes, soap and water, then rinsed with clear water preferably from a hose.

Schedule of Prices on Mo-Sai.—Base price of flat sheets, no returns, quartz or granite aggregates, $3.00 to $3.25 per sq. ft. with

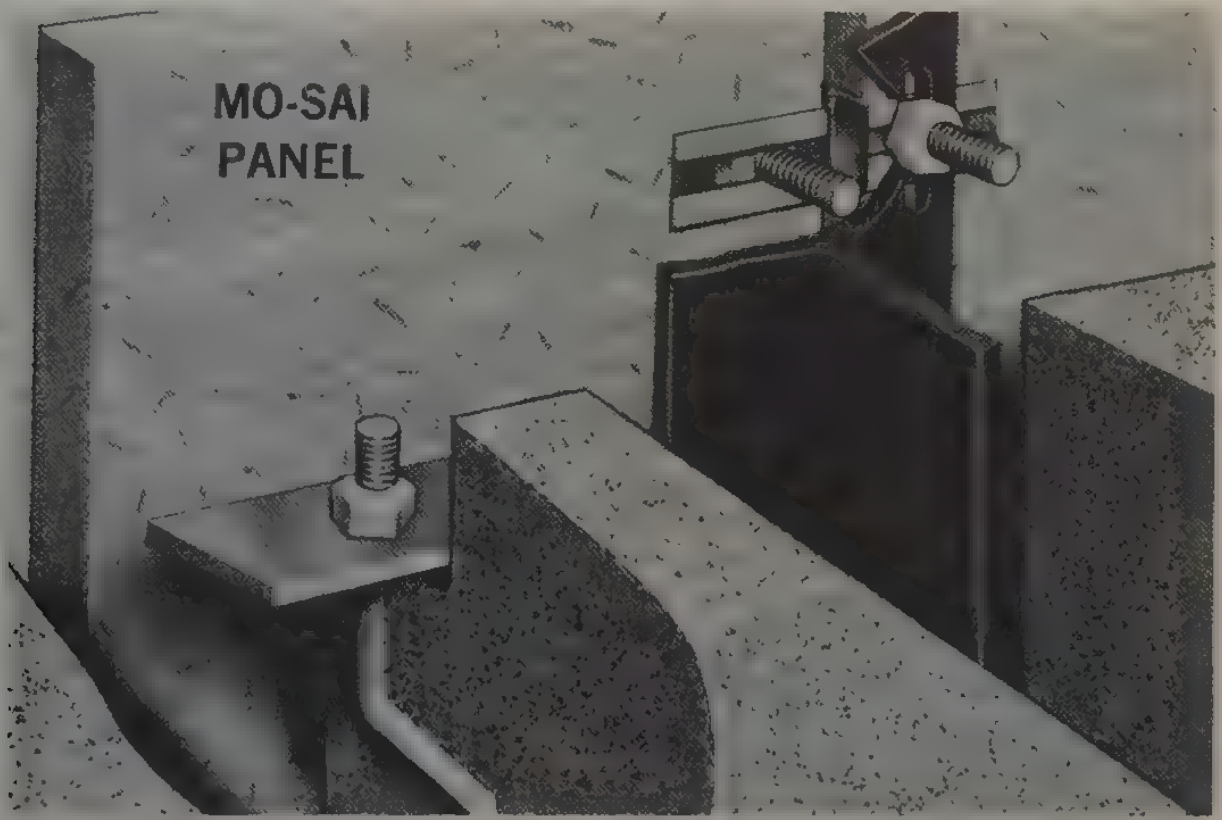
*Mo-Sai Institute, Inc., 110 Social Hall Ave., Salt Lake City, Utah.

Mo-Sai Faced Multi-Story Bldg.



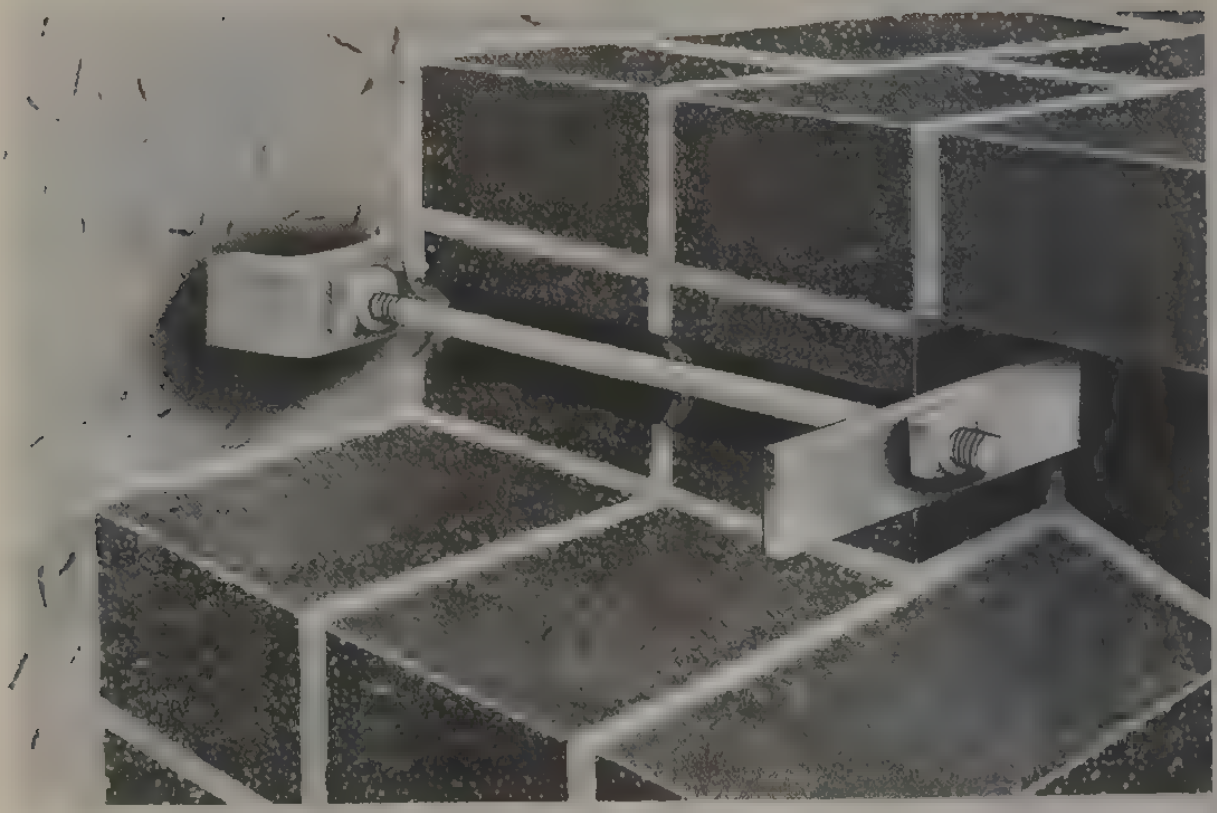
Mo-Sai Anchoring Details

Mo-Sai Used as Form

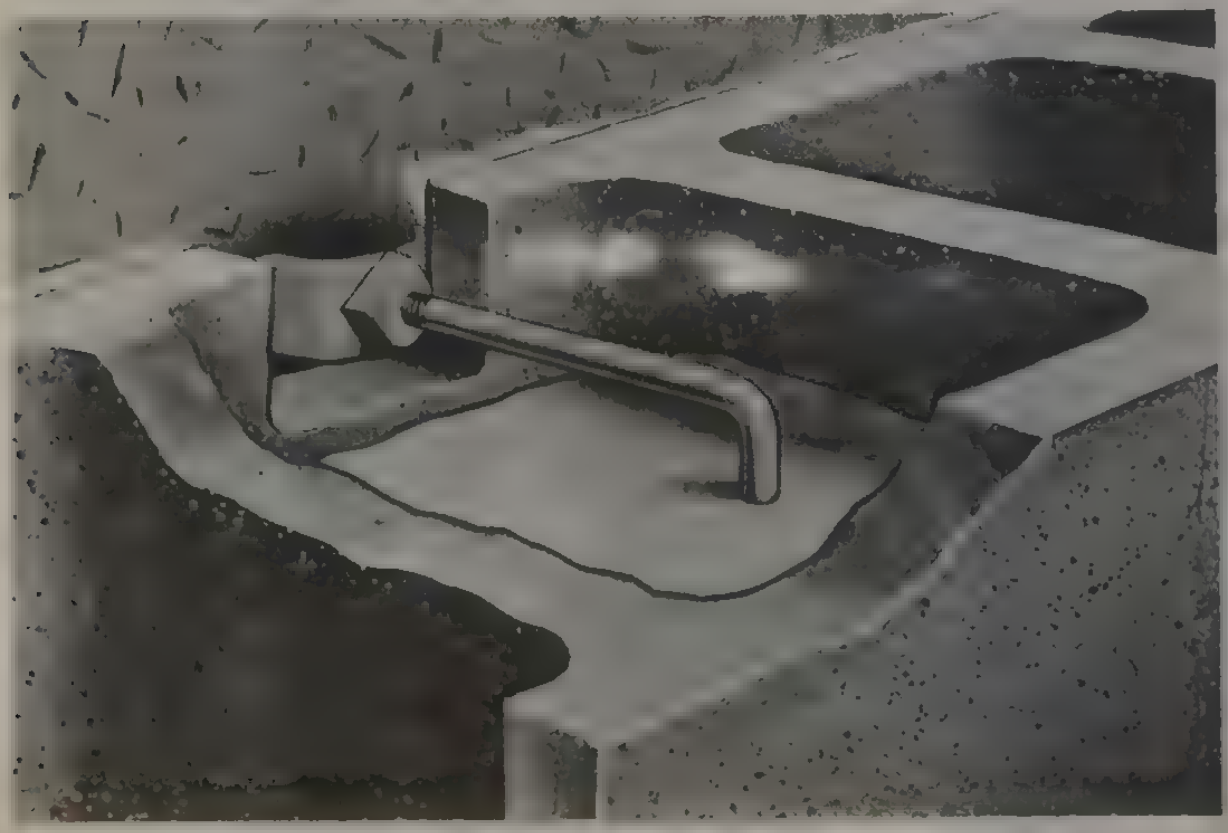


Mo-Sai to Concrete Wall

Methods of Anchoring Mo-Sai to Backup Materials



Mo-Sai Anchored to Brick



Mo-Sai to Concrete Block
Methods of Anchoring Mo-Sai to Various Materials

a minimum of 1,000 sq. ft. On jobs of less than 1,000 sq. ft. add $0.50 per sq. ft.

Returns up to 12", add $1.25 per lin. ft. of return.

Returns over 12" and not to exceed 24", add $1.75 per lin. ft. of return.

For all colored vitreous aggregates in flat sheets, add $3.50 per sq. ft. to base price.

Inlays ⅛" or ¼" deep and not over 2" wide, $1.50 per lin. ft. From 2" to 4" wide $2.00 per lin. ft. For each additional inch over 4", add $0.50 per inch of width.

Inlaid letters 8" and up, not over 2" wide $2.00 per lin. upright inch. Letters less than 8" in height, $2.50 per lin. upright inch. For letters under 4" in height, $3.00 per lin. upright inch. Plain letters 50 percent of the above prices.

False joints: due to the extremely wide variations in design, size and conformation in Mo-Sai slabs, it is suggested that the manufacturer be consulted.

The above prices are for Mo-Sai slabs delivered, f.o.b. trucks at site within a radius of 150 miles of the producing plant.

Labor Setting Mo-Sai.—The labor cost of handling and setting Mo-Sai slabs will run about the same as for stone or granite slabs of the same sizes, as they all have to be handled and set in much the same manner.

Ordinarily, this will run from $1.00 per sq. ft. in smaller cities, to $2.00 per sq. ft. in the large metropolitan areas. Costs for setting curtain wall application is generally lower than prices shown.

ARCHITECTURAL TERRA COTTA AND CERAMIC VENEER

Terra cotta is a building material made of a high grade clay (usually a mixture of several different kinds), to which is added a percentage of calcined clay to uniformly control the shrinkage and prevent undue warping.

Terra cotta is used for the same purposes as other building materials, like sandstone, limestone, granite, press brick, etc.; i.e., for interior or exterior trimmings or for entire fronts. It is also used extensively as glazed terra cotta for light courts,

for the interior walls of swimming pools, operating rooms in hospitals, clinics and patients' rooms, corridors, vestibules and stair halls (full height of wainscot) and in large kitchens where a ceramic material is required for sanitary purposes as well as for fire resisting advantages. It is used for service stations, power houses and rooms housing machinery on account of the ease with which it can be kept free from dust, dirt and grease. Its unlimited possibilities in color effects make it an ideal material for store fronts. It is used as a lining for the interior of restaurants, palm courts, hotels, residences and railroad stations. In stations and public buildings it is also used in the construction of ceilings and domes. In fact, it is a universal building material and has the advantage over other materials in that it may be produced in almost any color and may be glazed or unglazed with any surface treatment desired. It furnishes unlimited possibilities to the architect not only in color effect, but in the beauty of the original modeling in the plastic clay, an effect that cannot be obtained in carved stone except at tremendous cost.

Method of Manufacturing Architectural Terra Cotta.—After shop drawings have been approved, full size models are made of plaster to a shrinkage scale; to an increased size to allow for the shrinkage in drying and burning. A model is made for each different shape on the shop drawings. If a piece is ornamental, such ornament as may be required is modeled in clay and attached to the plaster model. From the models, sectional molds of plaster are cast, from which the required number of pieces of terra cotta are produced.

The mixture of clays and fusible materials used in forming terra cotta is carefully selected and proportioned to give the desired degree of plasticity when mixed with water. The composition must be such that when fired at high temperatures, it will produce a homogeneous body amply strong to support the required loads.

Forming terra cotta is a manual operation and consists of pressing the soft clay mixture into the molds. The walls of the pieces should be not less than one inch thick following the contour of the mold and the partitions should be properly sized and spaced to produce the strength required. The pressed piece remains in the mold until the clay stiffens, after which it is removed, retouched and placed in the drier where most of the moisture in the clay is removed.

Following the drying process the exposed surfaces of each piece re sprayed with the ceramic mixture which, when fired, develops nto the desired glaze color. The pieces are then placed in kilns nd fired by gradually increasing the temperature to 2,000° F. or nore, depending on the temperature of maturity of the clay and laze. After proper firing the kiln is allowed to cool slowly to ormal temperature.

After firing, the terra cotta is fitted for alignment by cutting r grinding and marked to correspond with the piece numbers on he shop drawings.

Method of Manufacturing Ceramic Veneer.—Ceramic veneer is he usual term applied to machine made architectural terra cotta nd the process of manufacturing is the same as for handmade ieces except that the material is extruded instead of hand pressed nto molds.

A machine mixes the proportioned clay with water and forces ne plastic mixture through a steel die which forms it into the esired shape. In most cases, before entering the die, the plastic nixture passes through a de-airing chamber where it is subjected o a partial vacuum and most of the entrapped air is removed. The pieces are then dried and surface finished to a true plane.

Subsequent operations are the same as for handmade pieces and nclude application of ceramic mixture, firing, fitting and mark- ng.

Cost of Architectural Terra Cotta and Ceramic Veneer.—In stimating the cost of architectural terra cotta and ceramic veneer here is no unit that may be taken as a definite basis for estimat- ng. All estimates are usually made by the manufacturer in a lump um price for the entire job.

To be able to accurately arrive at the cost of these materials, n estimator must have an intimate knowledge of the manufac- uring problems of the same. Each job is a custom job, there are o standard sizes, colors or shapes which are stocked.

One manufacturer suggests that the cost of architectural terra otta will vary from $350.00 to $500.00 and higher per ton and hat the cost of ceramic veneer will run from $2.50 to $4.00 and igher per sq. ft. The extreme range of these costs serves to mphasize the necessity for obtaining firm quotations from the nanufacturers.

Some of the conditions governing the costs of both architectural erra cotta and ceramic veneer are design of work, character and

amount of ornamentation, amount of duplication, sizes of piece color of glaze, weight, supply and demand, shipping condition etc.

Estimating Quantities of Architectural Terra Cotta and Ceramic Veneer.—When estimating quantities of terra cotta fro the plans or details, all measurements should be squared; i.e., a molded courses, cornices, round columns, column caps, base coursed ashlar, sills, copings, etc., should be figured from th extreme dimensions and reduced to cubic feet.

The weight of terra cotta varies from about 80 lbs. per cu. f for plain 4" thick ashlar to 60 lbs. per cu. ft. for large molde courses. For an average job about 72 lbs. per cu. ft., equivale to 28 cu. ft. per ton of 2,000 lbs. may be used.

After the quantities have been taken off the plans and reduce to cu. ft., they may either be priced in that manner, or mult plying the number of cu. ft. by 72 lbs. will give the total weigh of the terra cotta required for the job.

Ceramic veneer quantities are measured by the square foot are and should include all returns at doors, windows, soffits, etc.

Cost of Handling and Setting Architectural Terra Cotta.—Th labor cost of handling and setting architectural terra cotta wi vary with the sizes of the different pieces, the amount of dupl cation and the method used in handling and setting same.

Terra cotta weighs about one-half as much as stone, so that is seldom necessary to use derricks in handling and setting, a it is usually furnished in sizes that can be conveniently handle by 2 or 3 men. Considerable space is usually required on th job for storing the terra cotta, as it is sent to the job each piec marked to show its exact position in the building and must b carefully handled and placed in convenient piles for use as re quired. When handling the terra cotta on the job it is customar to load it into wheelbarrows or stone barrows and wheel it t the location where it is to be used. However, if it is necessar to hoist it to the upper floors or roof of the building the barrow can be placed on the material hoist, raised to the proper floo and then wheeled to the location where it is to be set.

Inasmuch as a great deal of terra cotta consists of trimming or 4" ashlar, it requires considerable handling to set a cubi foot. For instance, most ashlar being 4" thick, it is necessar to set terra cotta in 3 sq. ft. of wall to set one cu. ft. Thi also applies to sills, lintels, etc.

Based on the average job consisting of ashlar, sills, lintels, ornamental trimmings, etc., a mason will set about 35 to 40 cu. ft. (105 to 120 sq. ft. wall) per 8-hr. day, at the following cost per 100 cu. ft.:

	Hours	Rate	Total	Rate	Total
Terra cotta setter	21	$.....	$.....	$7.10	$149.10
Helper	21	.....	.....	5.00	105.00
Labor sorting, handling, wheeling, etc.	44	.....	.....	5.00	220.00
Hoisting engineer	5	.....	.....	6.00	30.00
Cost per 100 cu. ft.	91		$.....		$504.10
Cost per cu. ft.....			.....		5.04
Cost per sq. ft.			.....		1.68
Cost per ton (28 cu. ft.)..			.....		141.12

For labor cost of setting plain terra cotta wall ashlar, use same quantities and costs as given on the previous pages under "Glazed Structural Facing Tile."

On more complicated work consisting of gothic architecture, balusters and balustrade, glazed and enameled terra cotta, and other intricate work having a great deal of detail and requiring the utmost care in setting, a terra cotta setter will set only 20 to 25 cu. ft. (60 to 75 sq. ft. wall) per 8-hr. day, at the following cost per 100 cu. ft.:

	Hours	Rate	Total	Rate	Total
Terra cotta setter	36	$.....	$.....	$7.10	$255.60
Helper	36	.....	.....	5.00	180.00
Labor sorting, handling, wheeling, etc.	66	.....	.....	5.00	330.00
Hoisting engineer	8	.....	.....	6.00	48.00
Cost per 100 cu. ft.	146		$.....		$813.60
Cost per cu. ft.			.....		8.14
Cost per sq. ft.			.....		2.71
Cost per ton (28 cu. ft.) ..			.....		227.92

Small lintels and similar courses that have to be hung, may cost 25 to 50 percent higher than given above but these items are exceptional.

In general, the voids in architectural terra cotta should b completely filled with setting mortar or grout to prevent the pos sible accumulation of moisture in the cavities.

All supporting iron should be firmly embedded in masonr and completely covered with mortar to prevent rusting. Bronz or other non-corrosive metal or cadmium coated steel anchor should invariably be used for suspended features or for anchor ing or bracing free standing work.

Mortar Required for Setting Architectural Terra Cotta.—Unde average conditions it will require about 4 cu. ft. of mortar to se one ton of terra cotta, or about ½-cu. yd. of mortar per 100 cu. ft

The following proportions are recommended as being suitabl for making satisfactory mortar for setting terra cotta: On part standard portland cement, one part lime putty and six part sand.

One cu. yd. of setting mortar should cost as follows:

	Rate	Total	Rate	Total
4.5 sacks portland cement.....	$.....	$.....	$1.80	$ 8.10
196 lbs. hydrated lime.....	.....	.....	.02	3.92
1 cu. yd. sand	.....	.....	5.00	5.00
Cost per cu. yd.		$.....		$17.02
Cost per cu. ft.		.....		.63

Do not under any circumstances use plaster of Paris or sal in the mortar.

All exposed joints in projecting and overhanging features parapet work, and work standing free, should be raked out an pointed with a good asphaltic elastic cement.

Never use a cement that swells in setting for filling the void in terra cotta. Use only the best quality of cement.

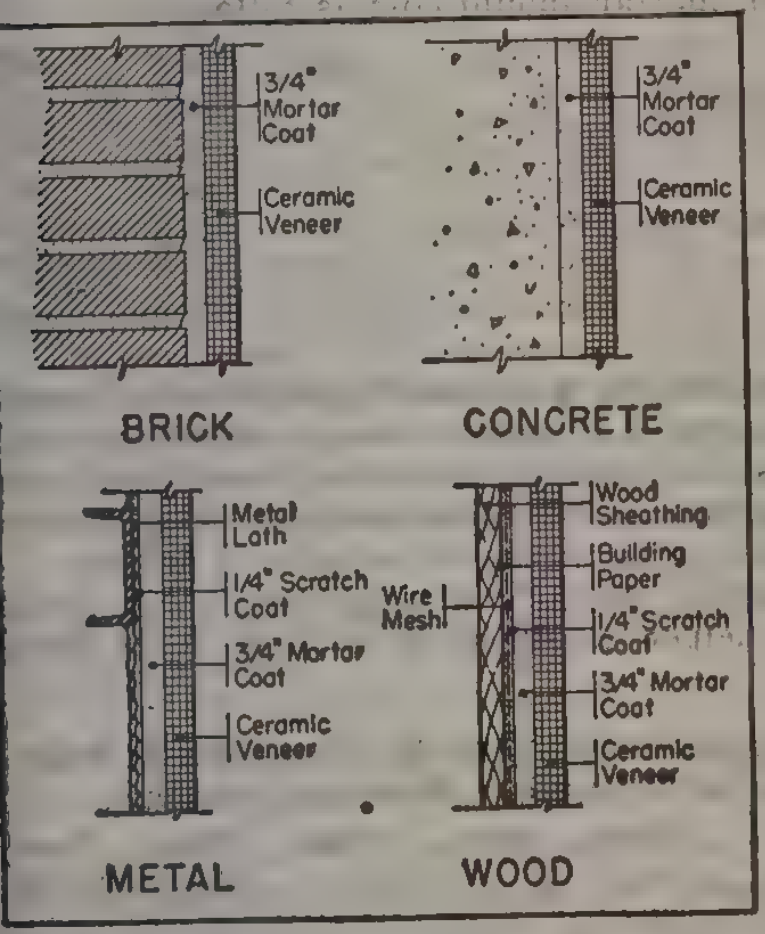
Handling and Setting Ceramic Veneer.—Ceramic veneer i available in two types, namely, adhesion type, commonly calle "thin" ceramic veneer, and anchored type.

Adhesion Type Ceramic Veneer.—Adhesion type ceramic venee is not over 1⅛" in thickness and the maximum face areas of indi vidual slabs do not exceed 540 sq. in. Maximum overall face di mensions are 18"x30" or 20"x27". Actual face dimensions wil vary with the manufacturer.

This type of ceramic veneer requires no metal anchorage. It is held in place by the adhesion of the mortar to the veneer body and the backing wall. The overall thickness from the face of the veneer to the face of the backing wall is 1¾" to 2".

Adhesion type ceramic veneer may be applied to a variety of ackings, such as concrete, masonry, wood and metal lath. Where ne backing is wood, a sheet of waterproof building paper should e installed first, followed by a layer of wire mesh. In the case f metal lath backing or wire mesh on wood backing, a ¼" scratch oat of mortar should be applied in advance of the setting of eneer slabs.

Setting Adhesion Type Ceramic Veneer.—Strict compliance with the manufacturer's recommendations for setting adhesion type ceramic veneer is necessary to assure the development of full shearing strength of veneer to backing. Step-by-step setting directions, recommended by manufacturers are as follows:



Method of Setting Adhesion Type Ceramic Veneer Terra Cotta to Brick, Concrete, Wood and Metal Lath Backing.

All units must be soaked in clean water for at least one hour before setting. The backing wall surface should also be damp at the time of setting. Immediately before setting, the backing wall and the backs of veneer units should both receive a brush coat of portland cement and water. One-half of the setting mortar should be spread on the back of the unit to be set and the other half on the wall surface to be covered. The unit is then set in place, using wood wedges to maintain correct bed joint thickness. Sufficient mortar should be used to create a slight excess which will be forced out of the joints from the back when the unit is tapped into place, thus eliminating all air pockets and filling all voids. Face joints may be pointed as soon as mortar has set sufficiently to support the veneer slabs. As a final step, the surface of the veneer should be washed down with clean water.

Mortar Required for Adhesion Type Ceramic Veneer.—Und average conditions, it will require 8 to 10 cu. ft. of mortar to s 100 sq. ft. of adhesion type ceramic veneer.

The following proportions are recommended as being suitab for making satisfactory mortar for setting adhesion type ceram veneer: Two parts portland cement, one part lime putty and eigl parts sand. A stearate type admix may be added to the mix i the proportions recommended by the manufacturer.

One cu. yd. of setting mortar should cost as follows:

	Rate	Total	Rate	Total
6.75 sacks portland cement.....	$.....	$.....	$1.80	$12.15
147 lbs. hydrated lime.....	.....	.....	.02	2.94
1 cu. yd. sand.....	.....	.....	5.00	5.00
10.13 lbs. stearate admix.....	.....	.....	.16	1.62
Cost per cu. yd.....		$.....		$21.71
Cost per cu. ft.....		.....		.80

Cost of Handling and Setting Adhesion Type Ceramic Venee —On most jobs, adhesion type ceramic veneer is delivered to th job in trucks and must be carefully unloaded, stored and prc tected in advance of the setting. Two laborers should do this wor at the rate of 360 to 400 sq. ft. of veneer area per 8-hr. day.

On the average job, where most of the veneer consists of typica panels, a mason and a helper should set 65 to 75 sq. ft. of venee per 8-hr. day.

Labor Cost Handling and Setting 100 Sq. Ft. Adhesion Type Ceramic Veneer on Concrete or Masonry Backing

Unloading and Storing	Hours	Rate	Total	Rate	Total
Labor	4.2	$.....	$.....	$5.00	$ 21.00
Setting					
Mason	11.5	.....	.....	7.10	81.65
Helper	11.5	.....	.....	5.00	57.50
Cost per 100 sq. ft.....	27.2		$.....		$160.15
Cost per sq. ft.....			.....		1.60

If veneer is to be applied to a backing of metal lath, add cos of ¼" scratch coat of mortar.

If veneer is to be applied to a wood backing, add cost of on layer of waterproof building paper, one layer of wire mesh an ¼" scratch coat of mortar.

Above costs do not include any allowance for cartage, scaf folding or hoisting. If hoisting is required, add 1-hr. hoistin engineer and 2-hrs. labor per 100 sq. ft. of veneer.

Anchored Type Ceramic Veneer.—Anchored type ceramic veneer is recommended where a larger size slab is desired. Anchored type slabs are available in face sizes considerably larger than the adhesion type, again depending upon the manufacturer. Ribs or scoring are provided on the backs of such units and the overall thickness of the slabs range from 2″ to 2½″. Depending on slab thickness, a total of 3″ to 4½″ is required from rough wall to finished veneer surface to provide adequate grout space between the veneer and the backing. Anchor holes are provided in the bed edges of the slabs for the installation of loose wire anchors which, in turn, are fastened to pencil rods anchored to the backing. Once the wire anchoring is in place, the units are bonded to the wall by a poured grout core.

Grout Required for Anchored Type Ceramic Veneer.—For ordinary work, it will require 20 to 25 cu. ft. of grout to fill the space back of 100 sq. ft. of anchored type ceramic veneer.

The following proportions are recommended for a suitable grout mix: One part portland cement, one part sand and five parts graded pea gravel passing a ¼″ sieve. Sufficient water should be added to cause the mixture to flow readily.

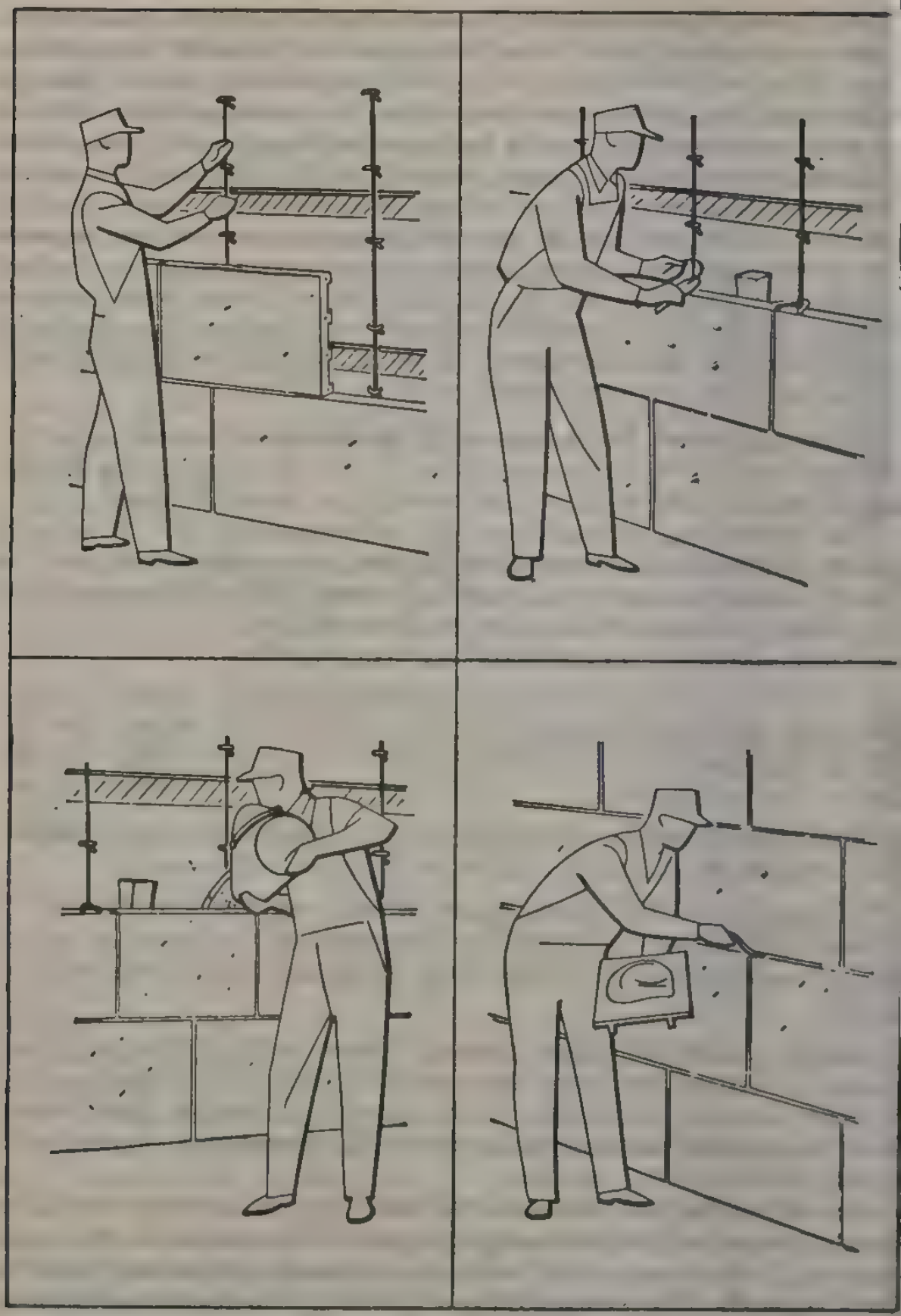
One cu. yd. of grout should cost as follows:

	Rate	Total	Rate	Total
5.4 sacks portland cement.....	$.....	$.....	$1.80	$ 9.72
0.2 cu. yd. sand.....	.....	.....	5.00	1.00
1.0 cu. yd. pea gravel.....	.....	.....	4.20	4.20
Cost per cu. yd.....		$.....		$14.92
Cost per cu. ft.....		.....		.55

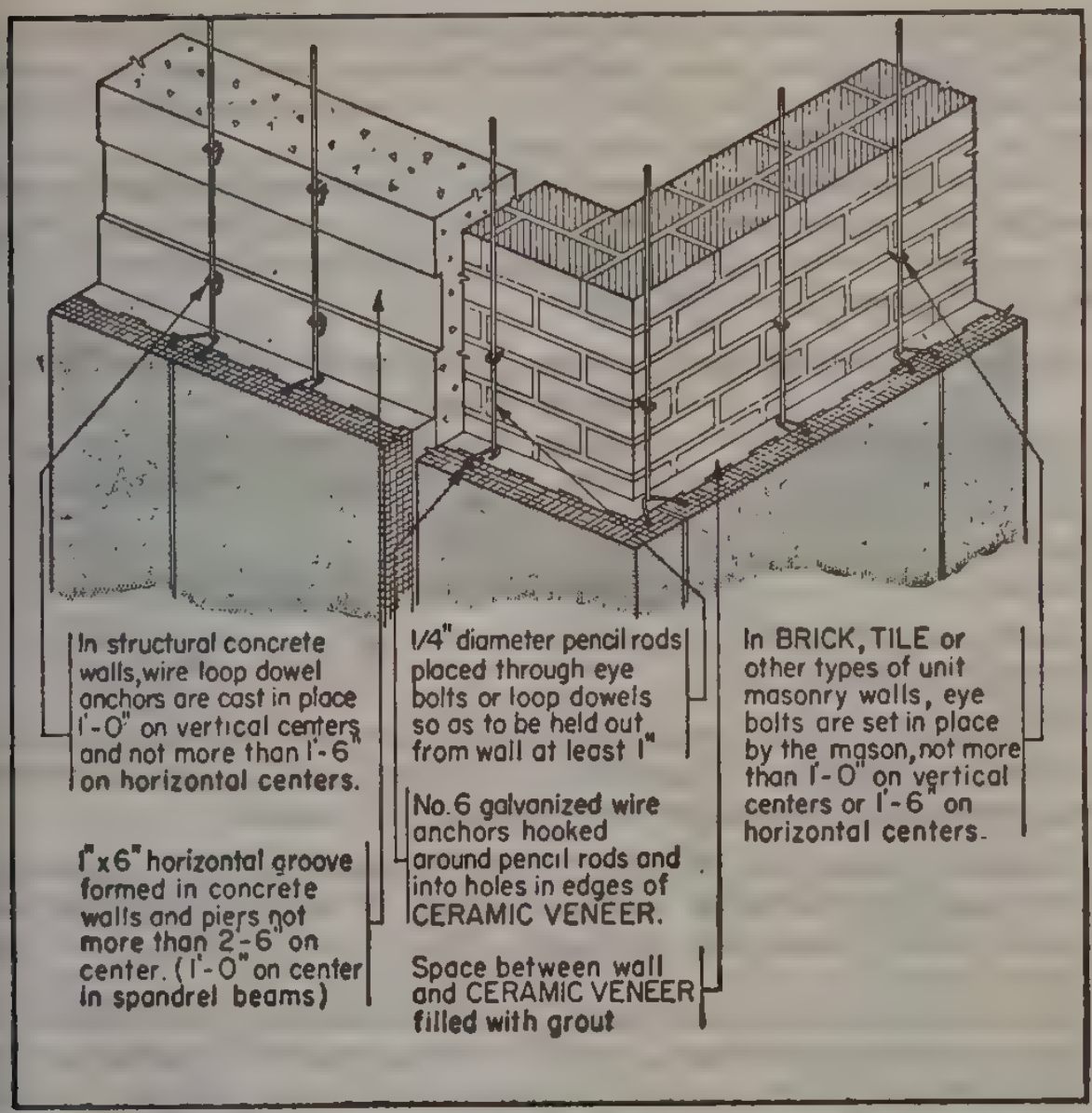
In addition to the above grout, it may require 1 to 2 cu. ft. of mortar per 100 sq. ft. of veneer for buttering the joints in setting to prevent leakage of grout. Any workable mortar mix may be used.

Setting Anchored Type Ceramic Veneer.—The following directions for setting anchored type ceramic veneer are recommended by the manufacturers. As in the case of adhesion type veneer, both units and backing wall should be thoroughly soaked with clean water prior to setting.

Assuming the backing wall has had loop tie inserts or eye bolts properly located, the first step in veneer slab erection is the insertion of ¼″ diameter pencil rods into the loops projecting from the backing wall. The veneer slabs are then set in place and secured to the pencil rods with wire anchors inserted in the top of each unit. Wood wedges should be used to maintain the proper joint



Illustrating Steps in Setting Anchored Type Ceramic Veneer


In structural concrete walls, wire loop dowel anchors are cast in place 1'-0" on vertical centers and not more than 1'-6" on horizontal centers.
1"x6" horizontal groove formed in concrete walls and piers not more than 2'-6" on center. (1'-0" on center in spandrel beams)
1/4" diameter pencil rods placed through eye bolts or loop dowels so as to be held out from wall at least 1"
No. 6 galvanized wire anchors hooked around pencil rods and into holes in edges of CERAMIC VENEER.
Space between wall and CERAMIC VENEER filled with grout
In BRICK, TILE or other types of unit masonry walls, eye bolts are set in place by the mason, not more than 1'-0" on vertical centers or 1'-6" on horizontal centers.

Method of Setting and Securing Anchored Type Ceramic Veneer Terra Cotta to Brick and Concrete Backing.

widths and the joints may be buttered with mortar or calked with rope yarn or other material to prevent grout leakage. Temporary wood wedges should also be used to hold each piece in place at the required distance from the backing wall.

When the setting of each horizontal row of units is completed, grout is poured into the space between the veneer and the backing, puddled thoroughly and allowed to set. Wedges may be removed and joints pointed when grout has set sufficiently to hold slabs in place. To complete the operation the finished veneer surface should be washed down with clean water.

Cost of Handling and Setting Anchored Type Ceramic Veneer.—Unloading, storing and protecting anchored type veneer slabs

is carried on in the same manner as for adhesion type slabs except that these units, being larger and heavier, are somewhat more difficult to handle. Two laborers should unload and store 320 to 360 sq. ft. anchored type slabs per 8-hr. day.

Setting anchored type veneer slabs is dependent on the size and weight of slabs, nature of design, etc., but on an average facing job a mason and a helper should set, grout and point 60 to 70 sq. ft. of veneer per 8-hr. day.

Labor Cost Handling and Setting 100 Sq. Ft. Anchored Type Ceramic Veneer

Unloading and Storing	Hours	Rate	Total	Rate	Total
Labor	4.7	$.....	$.....	$5.00	$ 23.50
Setting					
Mason	12.3	.....	.....	7.10	87.33
Helper	12.3	.....	.....	5.00	61.50
Cost per 100 sq. ft.	29.3		$.....		$172.33
Cost per sq. ft.			.....		1.72

The above costs do not include any allowance for cartage, scaffolding or hoisting. If hoisting is required, add 1.5 hrs. hoisting engineer and 3 hrs. labor per 100 sq. ft. of veneer.

Cleaning Down or Washing Terra Cotta.—Broadly speaking, there are three different surface finishes in terra cotta; lustrous glazed, matt glazed and unglazed. The glazed surfaces are the easiest to clean.

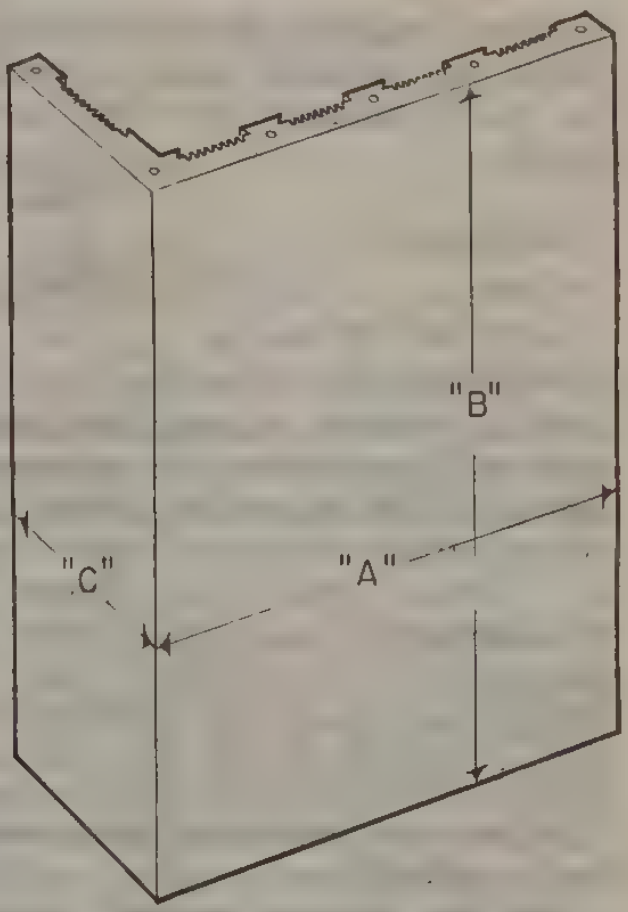
For both lustrous and matt glazed finishes a good abrasive soap or washing powder is best. Where required, there can be added to the latter a slight proportion of sharp sand. A stiff lather should be made and the surface scrubbed hard, allowing the lather to remain long enough to soften the dirt and then rinse off with clean water. Acid is not necessary for cleaning glazed surfaces.

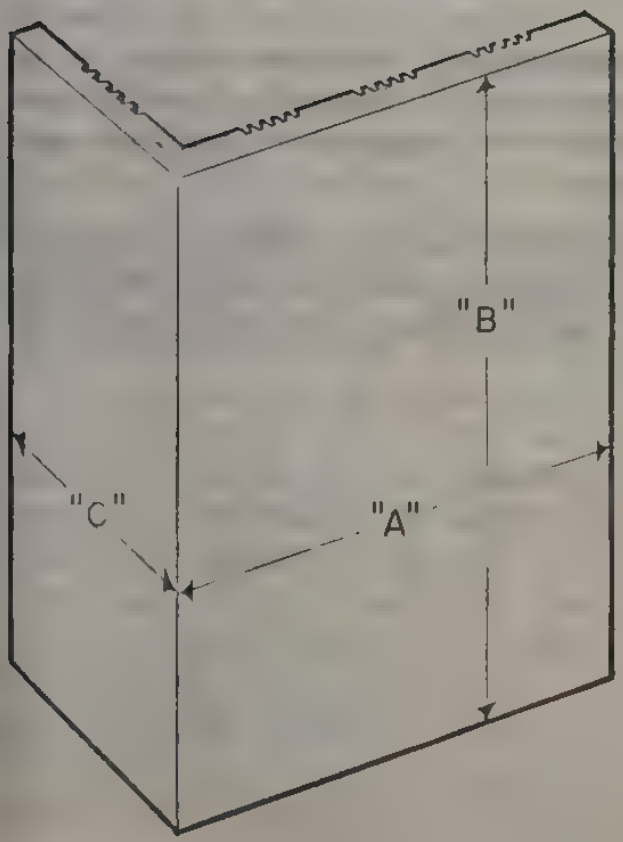
In cleaning unglazed terra cotta the addition of a slight proportion of commercial muriatic acid is recommended. The proportion of acid to water may be varied. One quart of acid to 4 gallons of water is sufficient in ordinary cases. In no event should it exceed 1½ pints of acid to one gallon of water and care should be taken to rinse off shortly after applying.

Where acid is employed use only wooden pails and fiber brushes. Metal pails cause a chemical reaction under which the solution becomes a yellow stain instead of a cleaning fluid. Do not permit hydrofluoric acid to be used. Many cleaners in order to save hand labor employ strong solutions of this which are highly injurious.

A	B	C
36"	4' 4"	14¾"
29¾"	4' 3"	14¾"
27¾"	4' 3"	11¾"
25¾"	4' 3"	11¾"
23¾"	4' 3"	11¾"
21¾"	3' 6"	7¾"
20¾"	3' 6"	7¾"
19¾"	3' 6"	7¾"
18¾"	3' 0"	7¾"
17¾"	3' 0"	7¾"

MAXIMUM SIZES AVAILABLE IN ANCHORED TYPE CERAMIC VENEER





A	B	C
5¾"	2' 0"	3¾"
7¾"	2' 0"	3¾"
11¾"	2' 0"	3¾"
1' 2¾"	2' 2"	3¾"
1' 3¾"	2' 2"	3¾"

MAXIMUM SIZES AVAILABLE IN ADHESION TYPE CERAMIC VENEER

When washing down unglazed terra cotta, on new work or work that is fairly clean, a tuckpointer should wash 600 to 800 sq. ft. of surface per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Tuckpointer	1.1	$.....	$.....	$7.50	$8.25
Helper	0.6	.....	.....	5.00	3.00
Cost per 100 sq. ft.	1.7		$.....		$11.25
Cost per sq. ft.					.11

When washing down glazed terra cotta, on new work or work that is fairly clean, an experienced tuckpointer should wash 800 to 1,000 sq. ft. per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Tuckpointer	1.0	$.....	$.....	$7.50	$7.50
Helper	0.5	.....	.....	5.00	2.50
Cost per 100 sq. ft.	1.5		$.....		$10.00
Cost per sq. ft.			.....		.10

Allow one helper on the ground to each 2 tuckpointers or to each scaffold.

Add for cartage, scaffold, tuckpointing contractor's social security tax and workmen's compensation insurance, overhead expense and profit.

Pointing Terra Cotta.—Recommended practice today is to strike the joints as the work progresses. Pointing mortar applied afterward is usually of different composition and accordingly of questionable permanency.

Cold Weather Protection.—Architectural terra cotta or ceramic veneer should not be set in freezing temperatures or when freezing can be expected prior to 30 days after setting, without providing enclosures and temporary heat.

CHAPTER XV

ROUGH CARPENTRY

To estimate carpentry quantities and costs accurately, the estimator should possess a working knowledge of the trade and be familiar with job conditions. He should know how the various classes of work are constructed, where joists and studs should be doubled, where to place wood furring strips for walls and floors, openings requiring wood bucks, and where it is necessary to place wood grounds. These may appear to be small items but they are important, nevertheless. On one job the estimator taking off the carpentry quantities had figured wood bucks for all exterior window frames. He could read plans, but was an inside man and did not know how work was constructed on the job. Your estimator is like your fire insurance policy—an expense until you have a fire—and then it is the most highly treasured document in your possession.

When taking off lumber quantities from the plans, always estimate as closely as possible the exact quantity of each kind of lumber required. Some contractors estimate the cost of wood floors at a certain price per sq. ft. including joists, bridging, subfloor, deadening felt, furring strips and the finish wood flooring. Entering into the construction of such a floor are materials and labor operations of widely varying costs, yet certain contractors are content to estimate their work in this haphazard manner, and at the completion of the job have no more idea of their labor costs than before they took the job.

When estimating labor costs of rough carpentry, bear in mind the costs will vary with the class of work performed, with the ability of the carpenters employed and with the experience and executive ability of the foreman or superintendent in charge of the work.

Modern tools, such as electric hand saws, electric drills, sanders, etc., play a big part in reducing labor costs. For instance an electric handsaw will cut off a 2″x12″ plank in 4 or 5 seconds while it takes about a minute to do it by hand; it takes 4 to 5 minutes to rip a 12′-0″ plank 2″ thick when sawing by hand while an electric handsaw will do the work in

less than a minute. In other words, an electric saw will cu 10 to 20 times as fast as can be done by hand. The handlin cost remains the same in either instance but when sawing fo any length of time, a man can turn out three or four times a much work with an electric saw as by hand.

Another thing that should be considered is the cost of filin saws where there are a number of carpenters working. Thi will vary with the condition of the saw but on an average i will require ½-hr. to file a saw by hand, while an automatic sav filer will do the same work in ¼-hr. The same applies t circular saws used on saw rigs or electric hand saws, as thes can be filed in ½ to ¾-hr. by machine, while hand filing require nearly twice as much time.

The same thing applies to the use of electric drills, electri sanders, etc., so the contractor who is going to keep up with th procession must use modern, labor-saving tools and equipmen wherever possible.

Here is another thing that should be remembered by every contractor. No matter how carefully the plans have been measured and how much consideration they have been given before pricing, if the work is not executed in a businesslike manner, careful estimating will not avert losses.

Estimating Lumber Quantities

When estimating the quantity of lumber required for any job, the only safe method is to take off every piece of lumber required to complete that portion of the work. This is seldom done, however, and the following tables are given to simplify the work as much as possible and at the same time provide accurate material quantities.

Estimating Wood Joists.—When estimating wood joists, always allow 4" to 6" on each end of the joist for bearing on the wall.

To obtain the number of joists required for any floor, take the length of the floor in feet and divide by the distance the joists are spaced and add 1 to allow for the extra joist required at end of span.

Example: If the floor is 28 ft. long and 15 ft. wide, it will require 16-ft. joists to allow for wall bearing at each end. Assuming the joists are spaced 16" on centers, one joist will be required every 16" or every 1⅓ ft. In other words it will

require ¾ as many joists as the length of the span, plus one. Three-quarters of 28 equal 21, plus 1 extra joist at end, makes 22 joists 16 ft. long for this space.

The following table gives the number of joists required for any spacing:

Number of Wood Floor Joists Required for any Spacing

Distance Joists are Placed on Centers	Multiply Length of Floor Span by	Add Joists	Distance Joists are Placed on Centers	Multiply Length of Floor Span by	Add Joists
12 inches.....	1	1	36 inches.....	⅓ or .33	1
16 inches.....	¾ or .75	1	42 inches.....	2/7 or .29	1
20 inches.....	⅗ or .60	1	48 inches.....	¼ or .25	1
24 inches.....	½ or .50	1	54 inches.....	⅔ or .22	1
30 inches.....	⅜ or .40	1	60 inches.....	⅕ or .20	1

Number of Feet of Lumber B.M. Required per 100 Sq. Ft. of Surface When Used for Studs, Joists, Rafters, Wall and Floor Furring Strips, etc.

The following table does not include any allowance for waste in cutting, doubling joists under partitions or around stair wells, extra joists at end of each span, top or bottom plates, etc. These items vary with each job. Add as required.

Size of Lumber	12-Inch Centers	16-Inch Centers	20-Inch Centers	24-Inch Centers
1"x2"	16⅔	12½	10	8⅓
2"x2"	33⅓	25	20	16⅔
2"x4"	66⅔	50	40	33⅓
2"x5"	83⅓	62½	50	41⅔
2"x6"	100	75	60	50
2"x8"	133⅓	100	80	66⅔
2"x10	166⅔	125	100	83⅓
2"x12"	200	150	120	100
2"x14"	233⅓	175	140	116⅔
3"x6"	150	112½	90	75
3"x8"	200	133⅓	120	100
3"x10"	250	187½	150	125
3"x12"	300	225	180	150
3"x14"	350	262½	210	175

Number of Wood Joists Required for any Floor and Spacing

Length of Floor	Spacing of Joists 12"	16"	20"	24"	30"	36"	42"	48"	54"	60"
6	7	6	5	4	3	3	3	3	2	2
7	8	6	5	5	4	4	3	3	3	2
8	9	7	6	5	4	4	3	3	3	3
9	10	8	6	6	5	4	4	3	3	3
10	11	9	7	6	5	4	4	4	3	3
11	12	9	8	7	5	5	4	4	3	3
12	13	10	8	7	6	5	4	4	4	3
13	14	11	9	8	6	5	5	4	4	4
14	15	12	9	8	7	6	5	5	4	4
15	16	12	10	9	7	6	5	5	4	4
16	17	13	11	9	7	6	6	5	5	4
17	18	14	11	10	8	7	6	5	5	4
18	19	15	12	10	8	7	6	6	5	4
19	20	15	12	11	9	7	6	6	5	5
20	21	16	13	11	9	8	7	6	5	5
21	22	17	14	12	9	8	7	6	6	5
22	23	18	14	12	10	8	7	7	6	5
23	24	18	15	13	10	9	8	7	6	6
24	25	19	15	13	11	9	8	7	6	6
25	26	20	16	14	11	9	8	7	7	6
26	27	21	17	14	11	10	8	8	7	6
27	28	21	17	15	12	10	9	8	7	6
28	29	22	18	15	12	10	9	8	7	7
29	30	23	18	16	13	11	9	8	7	7
30	31	24	19	16	13	11	10	9	8	7
31	32	24	20	17	13	11	10	9	8	7
32	33	25	20	17	14	12	10	9	8	7
33	34	26	21	18	14	12	10	9	8	8
34	35	27	21	18	15	12	11	10	9	8
35	36	27	22	19	15	13	11	10	9	8
36	37	28	23	19	15	13	11	10	9	8
37	38	29	23	20	16	13	12	10	9	8
38	39	30	24	20	16	14	12	11	9	9
39	40	30	24	21	17	14	12	11	10	9
40	41	31	25	21	17	14	12	11	10	9

One joist has been added to each of the above quantities to take care of extra joist required at end of span.

Add for doubling joists under all partitions.

Estimating Quantity of Bridging.—It is customary to place a double row of bridging between joists about 6′-0″ to 8′-0″ on centers. Joists 10′-0″ to 12′-0″ long will require one double row of bridging or 2 pcs. to each joist.

Joists 14′-0″ to 20′-0″ long will require 2 double rows of bridging or 4 pcs. to each joist.

Bridging is usually cut from 1″x3″, 1″x4″, 2″x2″ or 2″x4″ lumber.

The following table gives the approximate number of pcs. and the lin. ft. of bridging required per 100 sq. ft. of floor.

Joists Up to 12 Feet Long				Joists Up to 20 Feet Long			
12-Inch Centers		16-Inch Centers		12-Inch Centers		16-Inch Centers	
No. Pcs.	Lin. Ft.	No. Pcs.	Lin. Ft.	No. Pcs.	Lin. Ft.	No. Pcs.	Lin. Ft.
20	30	16	24	40	60	32	48

Steel Bridging for Wood Joists.—Several types of steel bridging are available, fabricated from de-formed strip steel varying from 16 to 20 gauge in thickness. Some are galvanized while others are painted with black asphaltum or have a baked enamel finish. Stock sizes fit all joist depths and spacings encountered in average construction work—special sizes are available made to order.

Prices vary according to type, size, finish and quantity, but a fair average for galvanized bridging is 20 to 40 cts. per set.

Installation time is about 50 percent of that required for wood bridging and with many types can be done after subflooring is laid.

Estimating Number of Wood Studs.—When estimating the number of wood partition studs, take the length of each partition and the total length of all partitions.

If a top and bottom plate is required, take the length of the wood partition and multiply by 2. The result will be the number of lin. ft. of plates required.

If a double plate consisting of 2 top members and a single bottom plate is used, multiply the length of the wood partitions by 3.

Example: Find the quantity of lumber required to build a stud partition 16′-0″ long, 8′-0″ high, with studs spaced 16″ on centers and having single top and bottom plates. 16′-0″ = 192″. 192″ ÷ 16″ = 12 studs, plus 1 extra at the end equals 13 studs 8′-0″ long. Two top and bottom plates 16′-0″ long equal 32 lin. ft.

13 pcs. 2″x4″ — 8′-0″ = 69⅓′
2 pcs. 2″x4″ — 16′-0″ = 21⅓′
Total..... 90⅔′

After the total number of lin. ft. of lumber has been obtained, reduce to board measure, as above.

Feet of Lumber, B.M. Required for Wood Stud Partitions

2"x4" studs 16" on centers, with single top and bottom plates.

Length of Partition	Height of Partition 8'-0"	8'-6"	9'-0"	10'-0"	12'-0"
3'-0"	20	22	22	24	28
4'-0"	27	29	29	32	37
5'-0"	33	37	37	40	47
6'-0"	40	44	44	48	56
7'-0"	41	45	45	49	57
8'-0"	48	53	53	57	67
9'-0"	55	60	60	65	76
10'-0"	61	67	67	73	85
11'-0"	63	69	69	75	87
12'-0"	69	76	76	83	96
13'-0"	76	83	83	91	105
14'-0"	83	91	91	99	115
15'-0"	84	92	92	100	116
16'-0"	91	99	99	108	125
17'-0"	97	107	107	116	135
18'-0"	104	114	114	124	144
19'-0"	105	115	115	125	145
20'-0"	112	123	123	133	155
21'-0"	119	130	130	141	164
22'-0"	125	137	137	149	173
23'-0"	127	139	139	151	175
24'-0"	133	146	146	159	184
25'-0"	140	153	153	167	193
26'-0"	147	161	161	175	203
27'-0"	148	162	162	176	204
28'-0"	155	169	169	184	213
29'-0"	161	177	177	192	223
30'-0"	168	184	184	200	232
31'-0"	169	185	185	201	233
32'-0"	176	193	193	209	243
33'-0"	183	200	200	217	252
34'-0"	189	207	207	225	261
35'-0"	191	209	209	227	263
36'-0"	197	216	216	235	272
37'-0"	204	223	223	243	281
38'-0"	211	231	231	251	291
39'-0"	212	232	232	252	292
40'-0"	219	239	239	260	301

Add ⅔ ft. of lumber, b.m. for each lin. ft. of double top or bottom plate.

Number of Partition Studs Required for Any Spacing

Distance Apart Studs	Multiply Length of Partition by	Add Wood Studs
12 inches	1.0	1
16 inches	0.75	1
20 inches	0.60	1
24 inches	0.50	1

Add for top and bottom plates.

Number of Feet of Lumber Required Per Sq. Ft. of Wood Stud Partition Using 2"x4" Studs.

Studs spaced 16" on centers, with single top and bottom plates.

Length Partition in Feet	No. Studs Req'd	Ceiling Heights in Feet 8'-0"	9'-0"	10'-0"	12'-0"
2	3	1.25	1.167	1.13	1.13
3	3	0.833	.812	.80	.80
4	4	0.833	.812	.80	.80
5	5	0.833	.812	.80	.80
6	6	0.833	.812	.80	.80
7	6	0.833	.75	.75	.80
8	7	0.75	.75	.75	.70
9	8	0.75	.75	.75	.70
10	9	0.75	.75	.75	.70
11	9	0.75	.70	.70	.67
12	10	0.75	.70	.70	.67
13	11	0.75	.70	.70	.67
14	12	0.75	.70	.70	.67
15	12	0.70	.70	.70	.67
16	13	0.70	.70	.70	.67
17	14	0.70	.70	.70	.67
18	15	0.70	.70	.67	.67
19	15	0.70	.70	.67	.67
20	16	0.70	.70	.67	.67
For dbl. plate, add per sq. ft.		0.13	.11	.10	.083

For 2"x8" studs, double above quantities.

For 2"x6" studs, increase above quantities 50%.

Example: Find the number of feet of lumber, b.m. required for a stud partition 18'-0" long and 9'-0" high. This partition would contain 18x9=162 sq. ft.

The table gives 0.70 ft. of lumber, b.m. per sq. ft. of partition. Multiply 162 by 0.70 equals 113.4 ft. b.m.

Quantity of Bevel Siding Required Per 100 Sq. Ft. of Wall

Measured Size Inches	Actual Size Inches	Exposed to Weather	Pattern	Add for Lap	Ft. B.M. Req. per 100 Sq. Ft. Surface
½x 4	½x 3¼	2¾	Regular	46%	151
½x 5	½x 4¼	3¾	Regular	33%	138
½x 6	½x 5¼	4¾	Regular	26%	131
½x 8	½x 7¼	6¾	Regular	18%	123
⅝x 8	⅝x 7¼	6¾	Regular	18%	123
¾x 8	¾x 7¼	6¾	Rabbetted	18%	123
⅝x10	⅝x 9¼	8¾	Rabbetted	14%	119
¾x10	¾x 9¼	8¾	Rabbetted	14%	119
¾x12	¾x11¼	10¾	Rabbetted	12%	117

The above quantities include 5% for end cutting and waste.

Weights per 1000 ft.—½" thick 800 lbs. Red cedar 600 lbs.; ⅝" thick 1,000 lbs. Red cedar 750 lbs.; 1" thick 1,200 lbs. Red cedar 900 lbs.

Quantity of Drop Siding Required Per 100 Sq. Ft. of Wall

Measured Size Inches	Actual Size Inches	Exposed to Weather	Add for Lap	Ft. B.M. Req. per 100 Sq. Ft. Surface	Weight per 1000 Ft.
1x6	¾x5¼	5¼	14%	119	1800
1x8	¾x7¼	7¼	10%	115	2000

The above quantities include 5% for end cutting and waste.

Quantity of Shiplap Required Per 100 Sq. Ft. of Surface

Measured Size Inches	Actual Size Inches	Add for Lap	Ft. B.M. Req. per 100 Sq. Ft. Surface	Weight per 1000 Ft.
1x 8	¾x7¼	10%	115	2200
1x10	¾x9¼	8%	113	2200

The above quantities include 5% for end cutting and waste.

Quantity of Bead Ceiling and Partition Required Per 100 Sq. Ft. of Surface

Measured Size Inches	Actual Size Inches	Add for Width	Ft. B.M Req. per 100 Sq. Ft. Surface	Weight per 1000 Ft.
1x4	⅝x3¼	23%	128	1400
1x4	¾x3¼	23%	128	1800

The above quantities include 5% for end cutting and waste.

Quantity of Dressed and Matched (D & M) or Tongued and Grooved (T & G) Boards Required Per 100 Sq. Ft. of Surface

Measured Size Inches	Actual Size Inches	Add for Width	Ft. B.M. Req. per 100 Sq. Ft. Surface	Weight per 1000 Ft.
1x6	¾x5¼	14%	119	2100
2x6	1⅝x5¼	14%	238	2300

The above quantities include 5% for end cutting and waste.

Quantity of Plain Ends Softwood Flooring Required per 100 Sq. Ft. of Floor

Measured Size Inches	Actual Size Inches	Add for Width	Ft. B.M. Req. per 100 Sq. Ft. Surface	Weight per 1000 Ft.
1x3	$\frac{3}{4}$x2$\frac{3}{8}$	27%	132	1800
1x4	$\frac{3}{4}$x3$\frac{1}{4}$	23%	128	1900

The above quantities include 5% for end cutting and waste.

Quantity of End Matched Softwood Flooring Required Per 100 Sq. Ft. of Floor

Measured Size Inches	Actual Size Inches	Add for Width	Ft. B.M. Req. per 100 Sq. Ft. Surface	Weight per 1000 Ft.
1x3	$\frac{1}{16}$x2$\frac{3}{8}$	27%	130	1800
1x4	$\frac{1}{16}$x3$\frac{1}{4}$	23%	126	1900

The above quantities include 3% for end cutting and waste.

Quantity of Square Edged (S4S) Boards Required Per 100 Sq. Ft. of Surface

Measured Size Inches	Actual Size Inches	Add for Width	Ft. B.M. Req. per 100 Sq. Ft. Surface	Weight per 1000 Ft.
1x 4	$\frac{3}{4}$x 3$\frac{1}{2}$	14%	119	2300
1x 6	$\frac{3}{4}$x 5$\frac{1}{2}$	9%	114	2300
1x 8	$\frac{3}{4}$x 7$\frac{1}{4}$	10%	115	2300
1x10	$\frac{3}{4}$x 9$\frac{1}{4}$	8%	113	2300
1x12	$\frac{3}{4}$x11$\frac{1}{4}$	7%	112	2400

The above quantities include 5% for end cutting and waste.

LINEAL FOOT TABLE OF BOARD MEASURE

Number of Feet of Lumber, B.M., Per Lineal Foot of any Size.

2" x 4"=0.667	4"x 4"=1.333	8"x14"= 9.333
2" x 6"=1.	4"x 6"=2.	8"x16"=10.667
2" x 8"=1.333	4"x 8"=2.667	10"x10"= 8.333
2" x10"=1.667	4"x10"=3.333	10"x12"=10.
2" x12"=2.	4"x12"=4.	10"x14"=11.667
2" x14"=2.333	4"x14"=4.667	10"x16"=13.333
2" x16"=2.667	4"x16"=5.333	10"x18"=15.
2½"x12"=2.5	6"x 6"=3.	12"x12"=12.
2½"x14"=2.917	6"x 8"=4.	12"x14"=14.
2½"x16"=3.333	6"x10"=5.	12"x16"=16.
3" x 6"=1.5	6"x12"=6.	12"x18"=18.
3" x 8"=2.	6"x14"=7.	14"x14"=16 333
3" x10"=2.5	6"x16"=8.	14"x16"=18.667
3" x12"=3.	8"x 8"=5.333	14"x18"=21.
3" x14"=3.5	8"x10"=6.667	16"x16"=21.333
3" x16"=4.	8"x12"=8.	16"x18"=24.

Quarter Scale Drawing Plan of Valley Rafters. Run 12 Inches

1 Pitch of Roof	2 Rise and Run or Cut	3 Length in Inches Common Rafter per 12" of Run	4 Percent Increase in Length of Com. Rafter over Run	5*	6 Length in Inches Hip or Valley Rafters†
1/12	2 and 12	12.165	.014	1.014	17.088
1/8	3 and 12	12.369	.031	1.031	17.233
1/6	4 and 12	12.649	.054	1.054	17.433
5/24	5 and 12	13.000	.083	1.083	17.692
1/4	6 and 12	13.417	.118	1.118	18.000
7/24	7 and 12	13.892	.158	1.158	18.358
1/3	8 and 12	14.422	.202	1.202	18.762
3/8	9 and 12	15.000	.250	1.250	19.209
5/12	10 and 12	15.620	.302	1.302	19.698
11/24	11 and 12	16.279	.357	1.357	20.224
1/2	12 and 12	16.971	.413	1.413	20.785
13/24	13 and 12	17.692	.474	1.474	21.378
7/12	14 and 12	18.439	.537	1.537	22.000
5/8	15 and 12	19.210	.601	1.601	22.649
2/3	16 and 12	20.000	.667	1.667	23.324
17/24	17 and 12	20.809	.734	1.734	24.021
3/4	18 and 12	21.633	.803	1.803	24.739
19/24	19 and 12	22.500	.875	1.875	25.475
5/6	20 and 12	23.375	.948	1.948	26.230
7/8	21 and 12	24.125	1.010	2.010	27.000
11/24	22 and 12	25.000	1.083	2.083	27.785
11/12	23 and 12	26.000	1.167	2.167	28.583
Full	24 and 12	26.875	1.240	2.240	29.394

†Figures in last column are length of hip and valley rafters in inches for each 12 inches of common rafter run.

*Use figures in this column to obtain area of roof for any pitch. See explanation below.

To Obtain Area of Roofs For Any Pitch.—To obtain the number of square feet of roof area for roofs of any pitch, take the entire flat or horizontal area of the roof and multiply by the figure given in the fifth column (*), and the result will be the area of the roof. Always bear in mind that the width of any overhanging cornice must be added to the building area to obtain the total area to be covered. Example: Find the area of a roof 26'-0"x42'-0", having a 12" or 1'-0" overhanging cornice. Roof having a ¼ pitch. To obtain roof area, 26'-0"+1'-0"+1'-0"=

28'-0" width. 42'-0"+1'-0"+1'-0"=44'-0" length. 28 x 44=1232 or 1,232 sq. ft. of flat or horizontal area.

To obtain area at ¼ pitch: multiply 1,232 by 1.12*=1379.84 or 1,380 sq. ft. roof surface.

Add allowance for overhang on dormer roofs and sides.

TABLE OF BOARD MEASURE

Giving Contents in Feet of Joists, Scantlings and Timbers

Size in Inches	Length in Feet 10	12	14	16	18	20	22	24	26	28	30
1 x 2	1⅔	2	2⅓	2⅔	3	3⅓	....	....	....	....	....
1 x 3	2½	3	3½	4	4½	5	....	....	....	....	....
1 x 4	3⅓	4	4⅔	5⅓	6	6⅔	....	....	....	....	....
1 x 6	5	6	7	8	9	10	....	....	....	....	....
1 x 8	6⅔	8	9⅓	10⅔	12	13⅓	....	....	....	....	....
1 x10	8⅓	10	11⅔	13⅓	15	16⅔	....	....	....	....	....
1 x12	10	12	14	16	18	20	....	....	....	....	....
1¼x 4	4⅙	5	5⅚	6⅔	7½	8⅓	....	....	....	....	....
1¼x 6	6¼	7½	8¾	10	11¼	12½	....	....	....	....	....
1¼x 8	8⅓	10	11⅔	13⅓	15	16⅔	....	....	....	....	....
1¼x10	10 5/12	12½	14 7/12	16⅔	18¾	20⅚	....	....	....	....	....
1¼x12	12½	15	17½	20	22½	25	....	....	....	....	....
1½x 4	5	6	7	8	9	10	....	....	....	....	....
1½x 6	7½	9	10½	12	13½	15	....	....	....	....	....
1½x 8	10	12	14	16	18	20	....	....	....	....	....
1½x10	12½	15	17½	20	22½	25	....	....	....	....	....
1½x12	15	18	21	24	27	30	....	....	....	....	....
2 x 2	3⅓	4	4⅔	5⅓	6	6⅔	...	...	...	...	...
2 x 3	5	6	7	8	9	10	11	12	13	14	15
2 x 4	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16	17⅓	18⅔	20
2 x 6	10	12	14	16	18	20	22	24	26	28	30
2 x 8	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32	34⅔	37⅓	40
2 x10	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40	43⅓	46⅔	50
2 x12	20	24	28	32	36	40	44	48	52	56	60
2 x14	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56	60⅔	65⅓	70
3 x 4	10	12	14	16	18	20	22	24	26	28	30
3 x 6	15	18	21	24	27	30	33	36	39	42	65
3 x 8	20	24	28	32	36	40	44	48	52	56	60
3 x10	25	30	35	40	45	50	55	60	65	70	75
3 x12	30	36	42	48	54	60	66	72	78	84	90
3 x14	35	42	49	56	63	70	77	84	19	98	105

TABLE OF BOARD MEASURE

Giving Contents in Feet of Joists, Scantlings and Timbers

Size in Inches	Length in Feet										
	10	12	14	16	18	20	22	24	26	28	30
4x 4	13	16	19	21	24	27	29	32	35	37	40
4x 6	20	24	28	32	36	40	44	48	52	56	60
4x 8	27	32	37	43	48	53	59	64	69	75	80
4x10	33	40	47	53	60	67	73	80	87	93	100
4x12	40	48	56	64	72	80	88	96	104	112	120
4x14	47	56	65	75	84	93	103	112	121	131	140
6x 6	30	36	42	48	54	60	66	72	78	84	90
6x 8	40	48	56	64	72	80	88	96	104	112	120
6x10	50	60	70	80	90	100	110	120	130	140	150
6x12	60	72	84	96	108	120	132	144	156	168	180
6x14	70	84	98	112	126	140	154	168	182	196	210
6x16	80	96	112	128	144	160	176	192	208	224	240
8x 8	53	64	75	85	96	107	117	128	139	149	160
8x10	67	80	93	107	120	133	147	160	173	187	200
8x12	80	96	112	128	144	160	176	192	208	224	240
8x14	93	112	131	149	168	187	205	224	243	261	280
8x16	107	128	149	171	192	213	235	256	277	298	320
10x10	83	100	117	133	150	167	183	200	217	233	250
10x12	100	120	140	160	180	200	220	240	260	280	300
10x14	117	140	163	187	210	233	257	280	303	327	350
10x16	133	160	187	218	240	267	293	320	347	373	400
12x12	120	144	168	192	216	240	264	288	312	336	360
12x14	140	168	196	224	252	280	308	336	364	392	420
12x16	160	192	224	256	288	320	352	384	416	448	480
14x14	163	196	229	261	294	327	359	392	425	457	490
14x16	187	224	261	299	336	373	411	448	485	523	560
14x18	210	252	294	336	378	420	462	504	546	588	630
14x20	233	280	327	373	420	467	513	560	607	653	700
16x16	213	256	299	341	384	427	469	512	555	597	640
16x18	240	288	336	384	432	480	528	576	624	672	720
16x20	267	320	373	425	480	533	587	640	693	747	800
18x18	270	324	378	432	486	540	594	648	702	756	810
18x20	300	360	420	480	540	600	660	720	780	840	900
20x20	333	400	467	533	600	667	733	800	867	933	1000

Nails Required for Carpenter Work

The following table gives the number of wire nails in pounds for the various kinds of lumber per 1,000 ft., board measure, or

per 1,000 shingles and lath or per square (100 sq. ft.) of asphalt slate surfaced shingle, with the number of nails added for loss of material on account of lap or matching of shiplap, flooring, ceiling and siding of the various widths. The table gives the sizes generally used for certain purposes with the nailing space 16" on centers, and 1 or 2 nails per board for each nailing space.

DESCRIPTION OF MATERIAL	Unit of Measure	Size and Kind of Nail	Number of Nails required	Pounds of Nails required
Wood Shingles	1,000	3d Common	2,560	4 lbs.
Individual Asphalt Shingles	100 sq. ft.	7/8" Roofing	848	4 lbs.
Three in One Asphalt Shingles	100 sq. ft.	7/8" Roofing	320	1 lb.
Wood Lath	1,000	3d Fine	4,000	6 lbs.
Wood Lath	1,000	2d Fine	4,000	4 lbs.
Bevel or Lap Siding, 1/2"x4"	1,000'	6d Coated	2,250	*15 lbs.
Bevel or Lap Siding, 1/2"x6"	1,000'	6d Coated	1,500	*10 lbs.
Byrkit Lath, 1"x6"	1,000'	6d Common	2,400	15 lbs.
Drop Siding, 1"x6"	1,000'	8d Common	3,000	25 lbs.
3/8" Hardwood Flooring	1,000'	4d Common	9,300	16 lbs.
25/32" Hardwood Flooring	1,000'	8d Casing	9,300	64 lbs.
Subflooring, 1"x3"	1,000'	8d Casing	3,350	23 lbs.
Subflooring, 1"x4"	1,000'	8d Casing	2,500	17 lbs.
Subflooring, 1"x6"	1,000'	8d Casing	2,600	18 lbs.
Ceiling, 5/8"x4"	1,000'	6d Casing	2,250	10 lbs.
Sheathing Boards, 1"x4"	1,000'	8d Common	4,500	40 lbs.
Sheathing Boards, 1"x6"	1,000'	8d Common	3,000	25 lbs.
Sheathing Boards, 1"x8"	1,000'	8d Common	2,250	20 lbs.
Sheathing Boards, 1"x10"	1,000'	8d Common	1,800	15 lbs.
Sheathing Boards, 1"x12"	1,000'	8d Common	1,500	12½ lbs.
Studding, 2"x4"	1,000'	16d Common	500	10 lbs.
Joist, 2"x6"	1,000'	16d Common	332	7 lbs.
Joist, 2"x8"	1,000'	16d Common	252	5 lbs.
Joist, 2"x10"	1,000'	16d Common	200	4 lbs.
Joist, 2"x12"	1,000'	16d Common	168	3½ lbs.
Interior Trim, 5/8" thick	1,000'	6d Finish	2,250	7 lbs.
Interior Trim, 3/4" thick	1,000'	8d Finish	3,000	14 lbs.
5/8" Trim where nailed to jamb	1,000'	4d Finish	2,250	3 lbs.
1"x2" Furring or Bridging	1,000'	6d Common	2,400	15 lbs.
1"x1" Grounds	1,000'	6d Common	4,800	30 lbs.

*NOTE—Cement coated nails sold as two-thirds of pound equals 1 pound of common nails.

The following table gives the recommended nailing schedule for special (helically threaded) nails that are being used today throughout the building industry.

Recommended Nailing Schedule for Common Applications in Building Construction

APPLICATION	Nailed into	NAIL SIZE Inches	NAIL TYPE	HEAD		POINT		NAILING	SPACING o. c.	NAILS Per Joint
				Diameter	Type	Size	Type			
Mudsill, partition plate, 2"	Concrete	2½–2¾ x0 148	Sc-1z	5/16"	Checkered	Long	Dia.	Face	12"–24"	—
Ditto, in earthquake regions	Concrete	(3¼-) 3½ x0 250	Sc-1z	9/16"	Checkered	Med.	Ndl.	Face	24"–48"	—
Ditto, 3"	Concrete	4½ x0.250	Sc-1z	9/16"	Checkered	Med.	Ndl.	Face	24"–48"	—
Furring strips	Concrete	1½–1¾ x0.148	Sc-1z	5/16"	Checkered	Long	Dia.	Face	12"–24"	—
Mudsill	Mudsill	2½ x0 120	Sc-2	9/32"	Flat	Med.	Dia.	Toe	—	2
Sleepers	Mudsill	2½ x0 120	Sc-2	9/32"	Flat	Med.	Dia.	Toe	—	2
Joists	Mudsill	3¼ x0.135	Sc-2	5/16"	Flat	Med.	Dia.	Toe	—	2–3
Subflrg., 1" lumber, plywood	Mudsill, sleeper, joist	2⅛ x0 105	St-14	¼"	Flat, Csk.	Med.	Dia.	Face	6" & 12"	2(3)
Subflrg., 2" lumber, plywood	Mudsill, sleeper, joist	2⅞ x0.120	St-14	9/32"	Flat, Csk.	Med.	Dia.	Face	—	2(3)
Subflrg., ⅜"–½" plywood (dph.)	Mudsill, sleeper, joist	1½ x0 135	Hi-28	5/16"	Flat, Csk.	Med.	Dia.	Face	6" & 12"	—
Subflrg., ⅝" plywood (dph.)	Mudsill, sleeper, joist	1¾ x0.135	Hi-28	5/16"	Flat, Csk.	Med.	Dia.	Face	6" & 12"	—
Subflrg., ¾"plywd (dph.), part bd.	Mudsill, sleeper, joist	2 x0.148	Hi-28	5/16"	Flat, Csk.	Med.	Dia.	Face	6" & 12"	—
Subflrg , 1"–1⅛" plywood (dph) part. bd.	Mudsill, sleeper, joist	2½ x0.148	Hi-28	5/16"	Flat, Csk.	Med.	Dia.	Face	6" & 12"	—
Underlayment, ¼"–5/16" plywood	Subfloor	1 x0.083	St-16	3/16"	Flat, Csk.	Med.	Dia.	Face	6" & 6"–12"	—
Underlayment, ⅜"–½" plywood	Subfloor	1¼ x0.083	St-16	3/16"	Flat, Csk.	Med.	Dia.	Face	6" & 6"–12"	—
Underlayment, ⅜" plywood	Subfloor	1⅜ x0.098	St-16	¼"	Flat, Csk.	Med.	Dia.	Face	6" & 6"–12"	—
Underlayment, ½" plywood	Subfloor	1½ x0.098	St-16	¼"	Flat, Csk.	Med.	Dia.	Face	6" & 6"–12"	—
Underlayment, ⅝" plywood	Subfloor	1⅝ x0.098	St-16	¼"	Flat, Csk.	Med.	Dia.	Face	6" & 6"–12"	—
Underlayment, 3/16"–⅜" hardboard	Subfloor	1–1⅜ x0 083	St-15	3/16"	Flat, Csk.	Med.	Dia.	Face	6" & 12"	—
Flooring, T & G hardwood	Subfloor, joist, sleeper	2–2½ x0 115	Sc-4	13/64"	Casing	Blunt	Dia.	Toe	10"-18"	—
Flooring, T & G softwood	Subfloor, joist, sleeper	2–2½ x0.115	Sc-4	13/64"	Casing	Blunt	Dia.	Toe	10"–18"	—
Flooring, T & G hardwood, ⅜" and ½"	Subfloor, joist, sleeper	1–1¼ x0 072	Sc-4	9/64"	Casing	Blunt	Dia.	Toe	10"–18"	—
Flooring, T & G parquet	Subfloor	1½ x0.105	Sc-4	9/64"	Casing	Blunt	Dia.	Face	—	—
Framing plates	Stud	3¼ x0 135	Sc-2	5/16"	Flat	Med	Dia.	Face	—	2
Framing studs	Stud, cripple, lintel, sill	2½ x0 120	Sc-2	9/32"	Flat	Med.	Dia.	Face	16"–24"	—
Framing studs	Plate, cripple, lintel, sill	2½ x0 120	Sc-2	9/32"	Flat	Med.	Dia.	Toe	—	3
Framing sole plate	Mudsill	3¼ x0 135	Sc-2	5/16"	Flat	Med.	Dia.	Face	16"	—
Framing top plate	Lower top plate	3¼ x0 135	Sc-2	5/16"	Flat	Med.	Dia.	Face	24"	—
Trussed rafter assembly		3¼ x0 135	Sc-5	5/16"	Flat	Med	Dia.	Face	2½"–3"	Given
Trussed rafter assembly		2½ x0.120	Sc-5	9/32"	Flat	Med	Dia.	Face	2½"–3"	Given

See Notes, Key to Nail Types and Abbreviations on later page.

APPLICATION		NAIL SIZE Inches	NAIL TYPE	HEAD	POINT		NAILING	SPACING o c.	NAILS Per Joint
	Nailed into			Diameter Type	Size	Type			
Rafter, 4"	Top plate	3¼ x0.135	Sc-2	5/16" Flat	Med.	Dia.	Toe	—	3
Rafter, 4"	Top plate	6 x0.177	St-34	7/16" Flat	Med.	Dia	Face	—	2
Rafter, 4"	Top plate	7 x0.207	St-34	½" Flat	Med.	Dia.	Face	—	2
Rafter, 6", 8", 10"	Top plate	4-6 x0 177 7-9 x0.203	St-34	7/16" Flat	Med.	Dia.	Toe	—	2-3
Sheathing, 1" lumber	Framing, rafter	2 x0 120	St-3	9/32" Flat	Med.	Dia.	Face	—	2
Sheathing ⅜"–½" plywood	Framing, rafter	1¾ x0.120	St-17	9/32" Flat	Med.	Dia.	Face	6" & 12"	—
Sheathing, 5/16"-½" plywood (dph.)	Framing, rafter	1½ x0.135	Hi-17	5/16" Flat, Csk.	Med.	Dia	Face	6" & 12"	—
Sheathing, ⅜" plywood (dph.)	Framing, rafter	1¾ x0.135	Hi-17	5/16" Flat, Csk.	Med.	Dia.	Face	6" & 12"	—
Sheathing, ¾" plywood (dph.)	Framing, rafter	2 x0.148	Hi-17	5/16" Flat, Csk.	Med.	Dia.	Face	6" & 12"	—
Sheathing, 1"–1⅛" plywood (dph.)	Framing, rafter	2½ x0.148	Hi-17	5/16" Flat, Csk.	Med.	Dia.	Face	6" & 12"	—
Sheathing, insulation board, gypsumboard	Framing, rafter	1½–2 x0.120	St-10g	⅜", 7/16" Flat	Blunt	Dia.	Face	3-4" & 6-8"	—
Sheathing, asbestosboard, ⅛"	Framing, rafter	1¼ x0.083	St-6g	3/16" Flat, Csk.	Blunt	Dia.	Face	3 4" & 6-8"	—
Sheathing, asbestosboard, ¼"	Framing, rafter	1¼ x0.120	St- or Sc-6g	5/16" Flat, Csk.	Blunt	Dia.	Face	3-4" & 6 8"	—
Sheathing, hardboard, ⅜"–⅝"	Framing, rafter	2 x0.115	Sc-7g	13⅜4" Flat, Csk.	Med.	Ndl.	Face	3–4" & 6–8"	—
Building paper	Sheathing	½–¾ x0.105	Sq-30	15/16" Square	Med.	Dia.	Face	6"–12"	—
Stripping, ⅜"x3⅝"	Framing, joist, rafter	2 x0.120	St-3	9/32" Flat	Med.	Dia.	Face	—	2
Stripping, 1"x4"	Framing, joist, rafter	2½ x0.135	St-3	5/16" Flat	Med.	Dia.	Face	—	2
Stripping, 2"x3"	Framing, joist, rafter	3½ x0.165	St-3	⅝" Flat	Med.	Dia.	Face	—	2
Siding, wood, 1"	Sheathing and framing	2⅛ x0.101–0.115	St-14g	¼" Flat, Csk.	Med.	Dia	Face	—	—
Siding, wood, 1"	Sheathing and framing	2 x0 120	Dr-14	5/32" Flat, Csk.	Med.	Ndl.	Face	—	1
Siding, wood, 2"	Sheathing and framing	3 x0.135	Dr-14	5/32" Flat, Csk.	Med.	Ndl.	Face	—	1
Siding, plywood	Sheathing and framing	1⅞ x0.109	Dr-8	5/32" Casing	Med.	Ndl.	Face	6" & 12"	1
Siding, T & G wood	Sheathing and framing	1¾ x0.105	Sc-8	5/32" Casing	Med.	Dia.	Toe	6" & 12"	—
Siding, asbestos shingle	Sheathing and framing	1½–1¾ x0 105	Dr 33	3/16" Flat Button	Med.	Dia.	Face	—	Given
Siding, asbestos shingle	Sheathing and framing	1½–1¾ x0.083	St-19t	3/16" Flat	Med.	Dia	Face	—	Given
Siding, asbestos shingle	Sheathing and framing	1½–1¾ x0.076	St-20	3/16" Flat	Med.	Dia.	Face	—	Given
Siding, insulated brick, wood shingle	Sheathing and framing	1¾ x0.095	St-18ge	3/16" Flat	Med.	Dia.	Face	8"–12"	2
Siding, wood shingle	Insulating sheathing	1¾–2 x0 083	St-18ge	5/32" Finishing	Blunt	Dia.	Face	—	2
Siding, wood shingle	Insulating sheathing	1¾–2 x0.105	Dr-18	5/32" Finishing	Blunt	Dia.	Face	—	2
Siding, wood shingle	Plywood	1⅛ x0.102	Dr-18	3/16" Flat	Long	Dia	Face	—	2
Siding, hardboard	Framing	2-2½ x0.115	Sc-7z	13/64" Casing	Long	Ndl	Face	12"	—
Siding, hardboard battenboard	Framing	1½ x0.083	Sc-7z	9/64" Casing	Long	Ndl.	Face	12"	—

See Notes, Key to Nail Types and Abbreviations on later page.

APPLICATION		NAIL SIZE Inches	NAIL TYPE	HEAD		POINT		NAIL-ING	SPACING o. c.	NAILS Per Joint
	Nailed into			Diameter	Type	Size	Type			
Fascia, 1"	Framing, rafter	2½ x0.120	Sc-2g	9/32"	Flat	Med.	Dia.	Face	—	2
Fascia, 2" lumber	Framing, rafter	3¼ x0 135	Sc-2g	5/16"	Flat	Med.	Dia.	Face	—	2
Roofing, built-up	Sheathing	¾-1¼ x0.105	Sq-30	15/16"	Square	Med.	Dia.	Face	10"	—
Roofing, built-up	Poured gypsum	1½-1¾ x0.120	Sq-31	15/16"	Square	Med.	Dia.	Face	10"	—
Roofing, asphalt shingle	Sheathing	¾-2 x0.120	St-10g	⅜"	Flat	Blunt	Dia.	Face	—	2-3
Roofing, asphalt shingle	Sheathing	¾-2x.120-.135	Dr-10	⅜"	Flat	Blunt	Dia.	Face	—	2-3
Roofing, wood shingle	Sheathing	¾-2x.105-.120	Dr-18	3/16"	Flat	Blunt	Dia.	Face	—	2
Roofing, wood shingle	Sheathing	1¾-2 x0 083	St-18g	⅛"	Flat, Csk.	Blunt	Dia.	Face	—	2
Roofing, asbestos shingle	Sheathing	As for siding								
Roofing, aluminum (corr. and flat)	Rafter, purlin	1½-1¾ x0.145	Dr-10	13/32"	Flat*	Long	Dia.	Face	12"	—
Roofing, sheet metal (corr. and flat)	Rafter, purlin	1-3 x0.135	St- or	7/16"	Flat*	Long	Dia.	Face	12"	—
Roofing, glass fiber (corr. and flat)	Rafter, purlin	1½-3 x0 135	Sc-9g	7/16"	Flat*	Long	Dia.	Face	12"	—
Roofing, glass fiber (corr. and flat)	Rafter, purlin	1½-3 x0.148	Dr-9 or 10	7/16"	Flat*	Long	Dia.	Face	12"	—
				*With Neoprene washer attached						
Lath, expanded metal, K-lath	Framing, joist	1½ x0.148	St-22g	L-Shaped		Med.	Dia.	Face	6" & 12"	—
Lath, gypsum plasterboard	Framing, joist	1¼ x0.101	St-23b	19/64"	Flat, Csk.	Long	Dia.	Face	5"	—
Gypsumboard, ⅜"	Framing, joist	1¼ x0.098	St-24	¼"-19/64"	Flat, Csk.	Long	Dia.	Face	5"-8"	—
Gypsumboard, ½"-⅝"	Framing, joist	1⅜ x0 098	St-24	¼"-19/64"	Flat, Csk.	Long	Dia.	Face	5"-8"	—
Gypsumboard, prefinished	Framing, joist	1⅜ x0 083	K-32e	3/16"	Flat, Csk.	Long	Dia.	Face	5"-8"	—
Paneling, trim		1-1¼ x0 054	K-32e	3/32"	Casing	Blunt	Dia.	Face	—	—
Paneling, trim, exterior		1-1½ x0.072	St-13	3/32"	Casing	Blunt	Dia.	Face	—	—
Paneling, trim, exterior		1 x0 065	St-12	3/32"	Casing	Blunt	Dia.	Face	—	—
Paneling, trim, exterior		1½ x0 076	Sc-12	3/32"	Oval	Blunt	Dia.	Face	—	—
Paneling, trim		1 x0 072	Sc-11	3/32"	Casing	Blunt	Dia.	Face	—	—
Paneling, trim		1½-1¾ x0 083	Sc-11	⅛"	Casing	Blunt	Dia.	Face	—	—
Paneling, trim		2½ x0 105	Sc-11	9/64"	Casing	Blunt	Dia.	Face	—	—
Acoustic tile		1-1¼ x0.062	St-25z	—		Blunt	Dia.	Face	—	—
Electric conduit	Wood	1½-2 x0 162	St-26z	1"	Hook	Blunt	Ndl.	Face	—	—
Electric conduit	Masonry	1½-2 x0.162	St-27z	1"	Hook	Blunt	Ndl.	Face	—	—
Fencing wire	Softwood (treated)	1½ x0 148	St-22g	L-Shaped		Med.	Dia.	Face	—	—
Fencing wire	Hardwood	1½ x0.148	St-21g	L-Shaped		Med.	Dia.	Face	—	—

See Notes, Key to Nail Types and Abbreviations on next page.

KEY TO NAIL TYPES

Sc-1z	Screw-Tite Masonry Nail, hardened HCS, zinc plated
Sc-2	Screw-Tite Framing Nail, hardened HCS
Sc-2g	Screw-Tite Framing Nail, hardened HCS, galvanized
Sc-3	Screw-Tite Framing Nail, bright LCS
Sc-3g	Screw-Tite Framing Nail, bright LCS, galvanized
Sc-4	Screw-Tite Flooring Nail, hardened HCS
Sc-5	Screw-Tite Trussed Rafter Nail, hardened HCS
Sc-6g	Screw-Tite Asbestosboard Nail, hardend HCS, galvanized
Sc-7g	Screw-Tite Exterior Hardboard Nail, hardened HCS, galvanized
Sc-7z	Screw-Tite Exterior Hardboard Nail, hardened HCS, zinc plated
Sc-8	Screw-Tite Casing Nail, silver bronze
Sc-9g	Screw-Tite Roofing Nail, hardened HCS, galvanized
Sc-10g	Screw-Tite Roofing Nail, bright LCS, galvanized
Sc-11	Screw-Tite Finishing Nail, bright LCS
Sc-12	Screw-Tite Finishing Nail, stainless steel
St-3	Stronghold Framing Nail, bright LCS
St-4	Stronghold Parquet Flooring Nail, hardened HCS
St-6g	Stronghold Asbestosboard Nail, hardened HCS, galvanized
St-9g	Stronghold Roofing Nail, hardened HCS, galvanized
St-10g	Stronghold Roofing Nail, bright LCS, galvanized
St-12	Stronghold Finishing Nail, stainless steel
St-13	Stronghold Finishing Nail, monel metal
St-14	Stronghold Sinker Nail, bright LCS
St-14g	Stronghold Sinker Nail, bright LCS, galvanized
St-15	Stronghold Underlay Nail, hardened HCS
St-16	Stronghold Underlay Nail, bright LCS
St-17	Stronghold Sheathing Nail, bright LCS
St-18g	Stronghold Shingle Nail, bright LCS, galvanized
St-18ge	Stronghold Shingle Nail, bright LCS, galvanized and enameled
St-19t	Stronghold Shingle Nail, bronze, tin plated
St-20	Stronghold Shingle Nail, stainless steel
St-21g	Stronghold Fence Staple, hardened HCS, galvanized
St-22g	Stronghold Fence Staple, bright LCS, galvanized
St-22z	Stronghold Fence Staple, bright LCS, zinc plated
St-23b	Stronghold Lath Nail, bright LCS, blued
St-24	Stronghold Drywall Nail, bright LCS
St-25z	Stronghold Kollarnail, hardened HCS, zinc plated
St-26z	Stronghold Conduit Staple, bright LCS, zinc plated
St-27z	Stronghold Knurled Conduit Staple, hardened HCS, zinc plated
St-34	Stronghold Spike, hardened HCS
Hi-28	"Hi-Load" Shear-Resistant Nail, bright LCS
Hi-17	"Hi-Load" Sheathing Nail, bright LCS
Sq-30	Squarehed Annular Thread Cap Nail, bright LCS
Sq-31	Squarehed Spiral Thread Cap Nail, bright LCS
K-32e	Annular Thread Kolorpin, bright LCS, enameled
Dr-8	Drive-Rite Spiral Thread Casing Nail, aluminum
Dr-9	Drive-Rite Screw Thread Roofing Nail, aluminum
Dr-10	Drive-Rite Spiral Thread Roofing Nail, aluminum
Dr-14	Drive-Rite Spiral Thread Sinker Nail, aluminum
Dr-18	Drive-Rite Screw Thread Shingle Nail, aluminum
Dr-20	Drive-Rite Spiral Thread Shingle Nail, aluminum
Dr-33	Drive-Rite Knurled Asbestos-Cement Shingle Face, aluminum

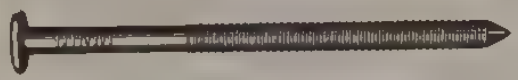
NOTES: For fastening redwood, use only aluminum or stainless steel nails.

Local conditions, customs and popular usage may dictate minor variations in length and gauge of nails. Consult the Technical Service Department of Independent Nail & Packing Company, Bridgewater, Mass.

The above chart is based on a table appearing in Bulletin No 38 (Revised Edition), "Better Utilization of Wood Through Assembly with Improved Fasteners," a study undertaken at Wood Research Laboratory, Virginia Polytechnic Institute, under the sponsorship of Independent Nail & Packing Company, Bridgewater, Mass., manufacturers of Stronghold® Annular Thread and Screw-Tite® Spiral Thread Nails and other improved fasteners.

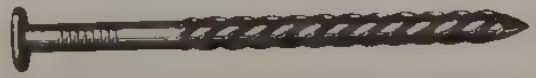
ABBREVIATIONS USED IN THIS TABLE:
Corr.—Corrugated
Dph.—Diaphragm
Part bd Particle board
LCS—Low Carbon Steel
HCS High Carbon Steel
Plywd.—Plywood
Csk.—Countersunk
Flrg.—Flooring
Shgl —Shingle
Med.—Medium
Dia.—Diamond
Ndl.—Needle

STRONGHOLD® ANNULAR THREAD NAIL

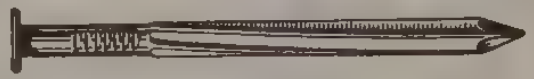


STRONGHOLD® SCREW THREAD NAIL

SCREW-TITE® SPIRAL THREAD NAIL



SCREW-TITE® KNURLED MASONRY NAIL



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Nails Required for Subflooring.—On wood floors up to 4" wide, quantities are based on 8d flooring nails. For flooring 6" and wider, 10d nails have been figured.

The quantities given below are sufficient to lay 1,000 ft. of flooring, b.m.

Width Flooring	Joist Spacing 12" on Centers	Joist Spacing 16" on Centers
2"	40 lbs. 8d flg.	30 lbs. 8d flg.
3"	30 lbs. 8d flg.	23 lbs. 8d flg.
4"	22 lbs. 8d flg.	17 lbs. 8d flg.
6"	24 lbs. 10d com.	18 lbs. 10d com.
8"	17 lbs. 10d com.	13 lbs. 10d com.

Data on Common Wire Nails

Size of Nails	Length of Nails Inches	Gauge Number	Approximate Number to Pound	Approx. Price Per 100 Lbs.
2d	1	15	876	$17.00
3d	1¼	14	568	15.60
4d	1½	12½	316	15.10
5d	1¾	12½	271	14.20
6d	2	11½	181	14.20
8d	2½	10¼	106	13.80
10d	3	9	69	13.60
12d	3¼	9	63	13.60
16d	3½	8	49	13.60
20d	4	6	31	13.60
30d	4½	5	24	13.60
40d	5	4	18	13.60
50d	5½	3	14	13.60
60d	6	2	11	13.60

Aluminum Nails

Aluminum nails are excellent for use whenever the nailhead is exposed to the atmosphere or corrosive conditions. In other words, use aluminum nails wherever there is the possibility of rust or nail stain.

The manufacturers do not ordinarily recommend aluminum common nails for ordinary framing because there is no economic advantage over steel wire nails for most common purposes and the bending resistance of aluminum nails is less than that of steel nails despite the larger diameter of the aluminum nails.

Aluminum nails weigh about one-third as much as steel wire nails but they are more expensive nail for nail however they do save labor and painting where rust or nail stain is a factor.

Estimating Data on Aluminum Nails

No. Nails Per Lb.	Type and Size of Nail	Coverage Per Box	No. Nails Per Box	Appr. Price Per Box
...	Alum. Shingles, .099"x1¼"	10 Sqs. Alum. Shingles	2666	$3.40
...	Alum. Shingles, .113"x1¼"	6 Sqs. Alum. Shingles	1570	2.65
550	Alum. Siding, 1½"		550	1.40
724	Cedar Shakes, 1¾"	3 Sqs. Double Course	1680	2.80
495	Insulated Siding, 2"	5 Sqs. Ins. Siding	1680	3.80
295	Insulated Siding, 2½"	60 Buttress Corners	600	2.30
318	Roofing, w/w/attached, 1¾"	5 Sqs. Alum. Roofing	525	3.20
285	Roofing, w/w/attached, 2"	5 Sqs. Alum. Roofing	525	3.40
215	Roofing, w/w/attached, 2½"	3 Sqs. Alum. Roofing	345	3.00
600	Wood Siding, Casing Hd., 6d	500 b.f. ½"x8" Siding	575	1.25
500	Wood Siding, Casing Hd., 7d	500 b.f. ¾"x8" Siding	575	1.50
343	Wood Siding, Casing Hd., 8d	500 b.f. ¾"x8" Siding	575	2.10
228	Wood Siding, Casing Hd., 10d	250 b.f. ¾"x8" Siding	290	1.80
566	Wood Siding, Sinker Hd., 6d	500 b.f. ½"x8" Siding	575	1.30
468	Wood Siding, Sinker Hd., 7d	500 b.f. ¾"x8" Siding	575	1.55
319	Wood Siding, Sinker Hd., 8d	500 b.f. ¾"x8" Siding	575	2.20
215	Wood Siding, Sinker Hd., 10d	250 b.f. ¾"x8" Siding	290	1.85

Also available in 50-lb. kegs at 7 to 15 percent less in price per pound, depending upon type and size of nail.

Hardware Accessories Used for Wood Framing

The following items may be used to advantage in all types of wood construction. Developed primarily to provide better joints between wood framing members, in many cases their use has resulted in lower overall costs—the additional material cost being more than offset by increased labor efficiency.

Steel Joist Hangers.—Used for framing joists to beams and around openings for stair wells, chimneys, hearths, ducts, etc. Made of galv. steel, varying from 12 ga. to $\frac{3}{16}$" in thickness, with square supporting arms, holes punched for nails and with bearing surfaces proportioned to size of lumber. Approximate prices for sizes most commonly used are as follows:

Joist Size	Gauge	Depth of seat	Opening in Hanger	Price Each
2"x 6"	12	2"	1⅝"x5"	$0.52
2"x 8"	12	2"	1⅝"x5"	.58
2"x10"	12	2"	1⅝"x8½"	.62
2"x12"	10	2½"	1⅝"x8½"	.76
4"x 8"	11	2"	3⅝"x5¼"	.72
4"x10"	9	2"	3⅝"x5¼"	.84
4"x12"	$\frac{3}{16}$	2½"	3⅝"x8½"	1.32

Teco* Framing Accessories.—Used in light wood construction to provide face-nailed connections for framing members. Adaptable to most framing connections, they eliminate the uncertainties and weaknesses of toe-nailing. Manufactured of zinc-coated, sheet steel in various gauges and styles. Framing accessories are designed to provide nailing on various surfaces. Special nails, ap-

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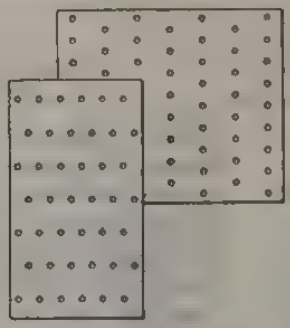
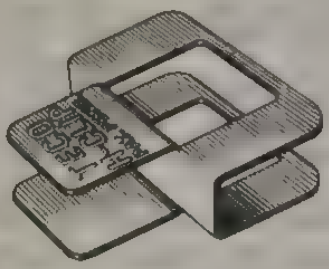
TECO TRIP-L-GRIPS

TECO DU-AL-CLIPS



TECO TRUSS PLATES

TECO POST CAPS



TECO H-CLIPS

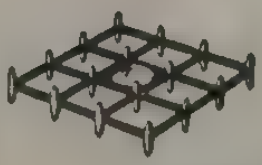
TECO ANGLES

proximately equal to 8d common nails, but only 1¼" long, to prevent complete penetration of standard nominal 2" lumber, are furnished with anchors. Approximate prices are as follows:

Type	Price Per 100	Type	Price Per 100
Trip-L-Grips	$15.50	Post Caps	$26.50
Du-Al-Clip	20.00	H Clips	25.00
Truss Plates	22.00	Angles	20.00

Split Ring

Toothed Ring



Spike Grids

Shear Plates

Teco Timber Connectors

Teco* Timber Connectors.—Timber connectors are devices for increasing the strength of bolted joints in timber construction. They are placed between adjacent faces of overlapping members, embedded to half-depth in each, to increase the bearing area at the connection. Several types of timber connectors are available, each for a particular purpose, as follows:

Teco* Wedge-Fit Split Rings.—Split ring connectors are hot-rolled carbon steel bands, bent to form a ring with a tongue and groove meeting joint. Cross-section of steel band is tapered both ways from center to edges, providing a wedge-fit when connectors are inserted into tapered grooves, conforming to ring section, and precut to half-depth in each contact face of overlapping members.

Grooves in wood members must be cut with a special grooving tool, using a power drill press or portable drill. Grooves and bolt holes may be cut in a single operation, using a combination grooving tool and drill bit. If bolt holes are bored first, a smooth shank pilot is used to guide the grooving tool.

Split rings are available in two sizes—2½" diameter rings are used for wood framing involving lumber of 2" nominal dimension and are used in trussed rafter construction for spans up to 50 ft.—4" diameter rings are used for medium to heavy construction, generally with members 3" or more in nominal thickness. Approximate prices of split rings and grooving tools are as follows:

Description	Approximate Prices 2½" Dia.	4" Dia.
Split rings, per 100 pcs.	$22.00	$36.00
Grooving tool cutter head, complete	40.00	60.00
Replacement cutters,		
Set of 4 for 2½" dia.	26.00	....
Set of 6 for 4" dia.	....	32.00
Smooth shank pilot,		
9/16" dia.	2.80	....
11/16" dia.	3.10	....
13/16" dia.	....	3.80
15/16" dia.	....	12.00

Teco* Shear Plates.—Shear plates are used for wood-to-steel connections and for wood structures that are frequently disassembled—used singly for wood-to-steel joints and in pairs for wood-to-wood assemblies. They are also often used, in place of split rings, for field connected joints. Shear plates are placed in daps precut in the contact faces of wood members with a special grooving tool. Load is transferred from wood member to

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shear plate, from shear plate to bolt and thence to opposing member, which may be another shear plate in wood, a steel gusset plate or rolled steel shape. Drilling, grooving and dapping of wood members are accomplished in the same manner as described for split ring connectors.

Shear plates are available in two sizes—2⅝" diameter, made of pressed steel, and 4" diameter made of malleable iron. Approximate prices of shear plates and grooving tools are as follows:

Description	Approximate Prices 2⅝" Dia.	4" Dia.
Shear plates, per 100 pcs.	$32.00	$44.00
Grooving tool cutter head, complete	45.00	60.00
Replacement cutters,		
Set of 3 for 2⅝" dia.	26.00	....
Set of 5 for 4" dia.	....	33.00
Smooth shank pilot,		
13/16" dia.	4.00	3.00
15/16" dia.	....	4.20

Teco* Toothed Rings.—Toothed ring connectors are toothed metal bands with each tooth corrugated or curved along its cross-section for greater rigidity. Used for wood-to-wood connections between lighter structural members. Also used for strengthening structures in place and structural repairs.

The function of toothed rings is similar to that of split rings, but the method of installation is not as efficient and requires more labor. Toothed rings are embedded in wood members by applying pressure. Where a large number of joints are to be assembled, a hydraulic jack set-up can be used to advantage. It requires a 5- to 7½-ton jack for single bolt connections and a 10-ton jack for joints with two bolts. Where fewer joints are involved, the high strength rod assembly is recommended. The assembly consists of a high strength rod with Acme threads on one end, double depth nuts, ball bearing thrust washer, heavy plate washers, lock washer and nut. Metal sleeve adaptors permit the use of ½", ⅝" or ¾" diameter rods with a standard ball bearing washer. The length of rod required equals the total thickness of wood members plus one inch for each layer of toothed rings plus 5 inches for nuts and washers. Ratchet wrenches help speed assembly—impact wrenches have also been used with success. After joint is drawn closed, high strength rod assembly is replaced with ordinary bolt and washers.

Toothed rings are manufactured of 16 gauge steel and are available in 2", 2⅝", 3⅝" and 4" diameters. Approximate prices of

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toothed rings, and high strength rod assembly parts are as follows:

Description	Approx. Price
Toothed rings, per 100 pcs.,	
2″ dia.	$12.50
2⅝″ dia.	13.50
3⅜″ dia.	14.50
4″ dia.	15.50
High strength rods,	
½″ dia.; 12″, 18″ or 24″ long; each	4.50
⅝″ dia.; 12″, 14″, 18″, 22″ or 24″ long; each	5.30
¾″ dia.; 12″, 14″, 18″, 22″ or 24″ long; each	6.00
Ball bearing washer, bored for ¾″ rod, each	3.00
Metal sleeve adaptor, for ½″ or ⅝″ dia. rods, each	2.80
Plate washers, per pair,	
4″x4″x⅜″	1.00
4″x4″x½″	1.50

Teco* Spike Grids.—Spike grid connectors are malleable iron castings of a grid-like structure with teeth protruding from both faces. Available in three styles—square flat type, 4⅛″x4⅛″ and circular type, 3¼″ dia., are used between sawn timbers –single curve type, 4⅛″x4⅛″, is used between curved faces of poles or piling and sawn timbers. Spike grids are embedded under pressure, using the high strength rod assembly, as previously described for toothed rings. Approximate prices are as follows:

Type of spike grid	Square Flat	Single Curve
Price per 100 pcs.	$85.00	$100.00

Labor Framing Lumber in Building Construction

The labor quantities and costs given in the following pages are intended to include all classes of frame construction, such as residences, ranch houses, barns, stables, apartment buildings, store and apartment buildings, country clubs, schools, and in fact all buildings that are constructed entirely of wood or have brick, stone, tile or cement block walls and wood joists, rafters, stud walls, partitions, wood subfloors, wall and roof sheathing, finish wood floors, etc.

Costs are given on two classes of workmanship. The classification "Ordinary Workmanship" is intended to cover the grade of workmanship encountered in most of our present day buildings where price is a factor. First Grade Workmanship designates the grade of workmanship demanded where quality

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is a factor as well as price, and is usually found in high-grade residences, apartments, hotel and office buildings, public buildings, high school, college and university buildings, etc.

The estimator must use his own judgment as to the grade of workmanship required, depending upon the type of building, the reputation of the architect, and the requirements of the specifications.

Another thing that is going to govern labor costs is the kind of equipment used, as the contractor who uses electric handsaws, drills, etc., will not have any trouble in outdistancing his competitors who are still working on the old handsaw basis.

All costs given on the following pages are based on using an electric saw for cutting all joists, studs and rafters to length, cutting off ends of subflooring, roof sheathing, etc. If an ordinary handsaw is used for this purpose, add 1 to 1½ hrs. carpenter time per 1,000 ft. b.m.

All of the labor quantities and costs on the following pages are based on laborers or helpers handling and carrying the lumber from the stock piles or benches where the lumber is being cut to length to the building. If the lumber is handled and carried by carpenters, figure labor time at carpenter wages.

Framing and Placing Foundation Wall Plates.—Where 2"x4" or 2"x6" wood plates are placed on top of foundation walls or concrete slab to receive the floor joists and exterior wall studs, it is customary to place anchor bolts in the walls and floors and the plates are then bored to receive the bolts, the plates are placed on the wall (and usually wedged with shingles) ready to receive the joists and exterior wall studs. Special purpose nails may be used for anchoring wall plates to concrete.

Where just an ordinary grade of workmanship is required, two carpenters working together should handle, frame and place 225 to 275 lin. ft. of 2"x4" or 2"x6" plates per 8-hr day, at the following cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	6.4	$.....	$.....	$6.75	$43.20
Cost per lin. ft.					.43

First Grade Workmanship

On jobs where first grade workmanship is required, with the foundation wall plates drilled for bolts, plates set and bedded absolutely level in a bed of cement mortar, two carpenters working together should handle, frame and place 175 to 225 lin. ft. of 2"x4" or 2"x6" wall plates per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	8	$.....	$.....	$6.75	$54.00
Cost per lin. ft.					.54

Framing and Placing Box Sills and Plates.—On platform framing, where a wood box sill and plate is formed by using a 2"x4" or 2"x6" plate and a 2"x8" or 2"x10" on the end of the joists to form a box sill, the wall plate should be drilled, leveled and set the same as described above, and the side or end piece is nailed after the joists are set.

This work should be estimated as given above for "Foundation Wall Plates" and the 2"x8" or 2"x10" end pieces should be figured in with the floor joists.

Framing and Erecting Exterior Stud Walls for Frame Buildings.—The labor cost of framing and erecting stud walls is subject to wide variation, depending upon the type of building, height, regularity of the walls, etc.

The framing on square or rectangular buildings, such as Cape Cod and colonial type houses and buildings of similar shape and construction will cost much less to frame than English type houses, having walls of irregular shape and height.

When you consider the average house requires only 1,500 to 2,500 ft. of lumber for outside stud walls, it shows just how much labor is required to frame it.

On square or rectangular shaped buildings, such as colonial, Georgian houses, etc., a carpenter should frame and erect 350 to 400 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	21.4	$.....	$.....	$6.75	$144.45
Labor	6	.....	.....	5.00	30.00
Cost 1,000 ft. b.m.	27.4		$.....		$174.45

On English type and other buildings having irregular wall construction, a carpenter should frame and erect 250 to 300 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	29.1	$.....	$.....	$6.75	$196.43
Labor	6	.....	.....	5.00	30.00
Cost 1,000 ft. b.m.	35.1		$.....		$226.43

First Grade Workmanship

In high class wood constructed buildings where every precaution is taken to prevent settling due to shrinkage, where the wood studs rest on masonry walls or steel I beams, and are not set on top of the floor joists and where it is necessary to bridge or truss between all studs, truss over door and window openings, etc., a carpenter should frame and erect 225 to 275

ft. of lumber, b.m. per 8-hr. day, on square or rectangular type buildings, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	32	$.....	$.....	$6.75	$216.00
Labor	8	.....	.....	5.00	40.00
Cost 1,000 ft. b.m.	40		$.....		$256.00

On English type and other buildings having irregular wall construction, a carpenter should frame and erect 150 to 200 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	45.7	$.....	$.....	$6.75	$308.48
Labor	8.0	.....	.....	5.00	40.00
Cost 1,000 ft. b.m.	53.7		$.....		$348.48

Framing Interior Stud Partitions.—When framing and setting interior stud partitions set on top of rough wood floors that require just the ordinary amount of framing for door openings, a carpenter should frame and erect 375 to 425 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	20	$.....	$.....	$6.75	$135.00
Labor	6	.....	.....	5.00	30.00
Cost 1,000 ft. b.m.	26		$.....		$165.00

First Grade Workmanship

Where the wood partition studs are set on masonry walls or steel I beams instead of the wood subfloor and where it is necessary to brace between studs and truss over all door openings, a carpenter should frame and erect 250 to 300 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	29.1	$.....	$.....	$6.75	$196.43
Labor	8.0	.....	.....	5.00	40.00
Cost 1,000 ft. b.m.	37.1		$.....		$236.43

Framing and Setting Floor Joists.—When framing and placing wood floor joists up to 2"x8" in buildings of regular construction, a carpenter should frame and place 550 to 600 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	13.9	$.....	$.....	$6.75	$93.83
Labor	4.5	.....	.....	5.00	22.50
Cost 1,000 ft. b.m.	18.4		$.....		$116.33

If 2"x10" or 2"x12" joists are used, a carpenter should frame and erect 600 to 650 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	12.8	$.....	$.....	$6.75	$86.40
Labor	4.0	.....	.....	5.00	20.00
Cost 1,000 ft. b.m.	16.8		$.....		$106.40

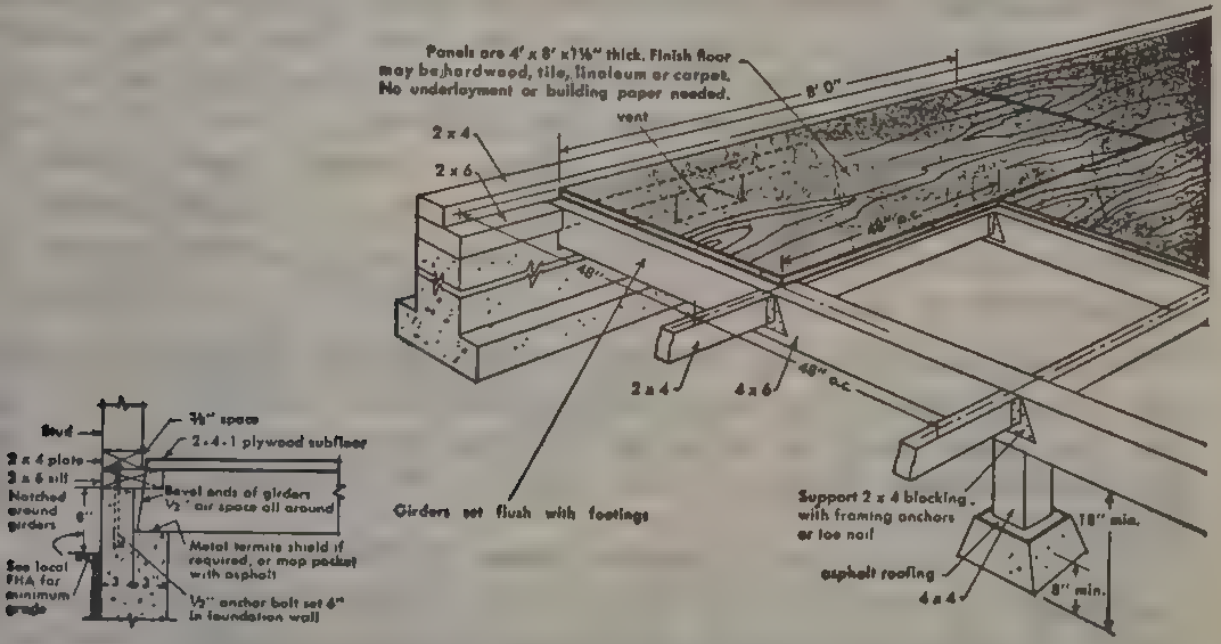
First Grade Workmanship

On jobs where the wood joists must be set with the crowning edge up and it is not permissible to block up under the joists with shingles or wood wedges, a carpenter should frame and erect 500 to 550 ft. b.m. (sizes up to 2"x8") per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	15.2	$.....	$.....	$6.75	$102.60
Labor	4.5	.....	.....	5.00	22.50
Cost 1,000 ft. b.m.	19.7		$.....		$125.10

Using 2"x10" or 2"x12" joists, a carpenter should frame and erect 550 to 650 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	13.9	$.....	$.....	$6.75	$93.83
Labor	4.0	.....	.....	5.00	20.00
Cost 1,000 ft. b.m.	17.9		$.....		$113.83


Panels are 4' x 8' x 1⅛" thick. Finish floor may be hardwood, tile, linoleum or carpet. No underlayment or building paper needed.
8' 0"
vent
2 x 4
2 x 6
48" o.c.
48"
2 x 4
4 x 6
48" o.c.
Girders set flush with footings
Support 2 x 4 blocking with framing anchors or toe nail
asphalt roofing
4 x 4
18" min.
8" min.
Bevel
2 x 4 plate
2 x 6 sill
Notched around girders
8"
See local FHA for minimum grade
⅜" space
2-4-1 plywood subfloor
Bevel ends of girders ½" air space all around
Metal termite shield if required, or mop pocket with asphalt
½" anchor bolt set 6" in foundation wall

Method of Framing Panel and Girder Floor Systems

Framing Panel and Girder Floor Systems.—When framing and placing 4"x6" wood beams and 2"x4" spacers to form 4-ft. square grids for panel and girder floor systems, 2 carpenters and a

helper should frame and place 1,500 to 1,700 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	10	$.....	$.....	$6.75	$67.50
Labor	5	.....	.....	5.00	25.00
Cost per 1,000 ft. b.m...	15		$.....		$92.50

Installing Cross-Bridging.—Under average conditions a carpenter should cut and place 90 to 110 sets (2 pieces) of cross-bridging per 8-hr. day at the following labor cost per 100 sets:

	Hours	Rate	Total	Rate	Total
Carpenter	8	$.....	$.....	$6.75	$54.00
Cost per set			.....		.54

Framing and Erecting Rafters for Gable Roofs.—When framing and erecting rafters for plain double pitch or gable roofs, without dormers or gables, and where 2"x6" or 2"x8" lumber is used, a carpenter should frame and erect 285 to 335 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	24.6	$.....	$.....	$6.75	$166.05
Labor	7.0	.....	.....	5.00	35.00
Cost 1,000 ft. b.m.....	31.6		$.....		$201.05

On buildings having double pitch or gable roofs, cut up with dormers and gables framing into the main roof, a carpenter should frame and erect 250 to 300 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	29.1	$.....	$.....	$6.75	$196.43
Labor	8.0	.....	.....	5.00	40.00
Cost 1,000 ft. b.m.....	37.1		$.....		$236.43

Framing and Erecting Rafters for Hip Roofs.—When framing and erecting plain hip roofs, without dormers or gables framing into the main roof, a carpenter should frame and erect 250 to 300 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	29.1	$.....	$.....	$6.75	$196.43
Labor	8.0	.....	.....	5.00	40.00
Cost 1,000 ft. b.m.....	37.1		$.....		$236.43

On difficult constructed hip roofs, where it is necessary to frame for dormers, gables, valleys, etc., a carpenter should

frame and erect 180 to 220 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	40	$.....	$.....	$6.75	$270.00
Labor	8	.....	.....	5.00	40.00
Cost 1,000 ft. b.m.	48		$.....		$310.00

Framing Light Timbers for Exposed Roof Beam Construction.—Light timbers, varying from 4"x6" to 4"x14" and larger, depending upon span and spacing, are used for exposed beam roof construction. This type of construction is now in wide use for contemporary design houses, stores, medical groups, small churches, etc., with flat or low rise sloping roofs.

On work of this type, two carpenters and a helper should frame and place 750 to 850 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	20	$.....	$.....	$6.75	$135.00
Labor	10	.....	.....	5.00	50.00
Cost per 1,000 ft. b.m.	30		$.....		$185.00

Framing for Roof Saddles on Flat Roofs.—On flat roofs where it is necessary to frame saddles to pitch the water toward the drains, and where the saddles are built up of 2"x4" framing covered with 1" sheathing, a carpenter should frame and erect 400 to 450 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	19	$.....	$.....	$6.75	$128.25
Labor	6	.....	.....	5.00	30.00
Cost 1,000 ft. b.m.	25		$.....		$158.25

Placing Wood Cant Strips.—When cant strips, diagonally cut from 4" x 4" or 6" x 6" lumber, occur in long runs with few breaks a carpenter should place 475 to 525 lin. ft. per 8-hr. day at the following labor cost per 100 lin. ft:

	Hours	Rate	Total	Rate	Total
Carpenter	1.6	$.....	$.....	$6.75	$10.80
Cost per lin. ft.			.....		.108

If cant strips occur in short runs, such as around roof opening curbs, or if the runs are cut up with pilasters and other breaks, a carpenter should place 300 to 325 lin. ft. per 8-hr. day at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.6	$.....	$.....	$6.75	$17.55
Cost per lin. ft.			.....		.176

Laying Rough Wood Floors.—When laying 1"x6" or 1"x8" rough wood subflooring, a carpenter should lay 825 to 925 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	9.2	$.....	$.....	$6.75	$62.10
Labor	5.3	.....	.....	5.00	26.50
Cost 1,000 ft. b.m.	14.5		$.....		$88.60

Laying Rough Wood Floors Diagonally.—When laying rough wood subflooring diagonally, making it necessary to cut both ends of the flooring on a bevel, a carpenter should lay 650 to 750 ft. of flooring b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	11.5	$.....	$.....	$6.75	$ 77.63
Labor	5.5	.....	.....	5.00	27.50
Cost 1,000 ft. b.m.	17.0		$.....		$105.13

Laying Wood Sheathing on Flat Roofs.—Figure same as given above for Rough Wood Floors.

Labor Laying Plywood Subflooring.—The labor cost of handling and laying plywood subflooring can vary widely, depending upon the size of the floor area, the regularity of the joist spacing and upon the method of laying.

When plywood is used as subflooring, nailed directly to the joists and with the finish floor applied directly to the plywood, all edges (both longitudinal and crosswise) should be nailed about 6" on centers, otherwise the finish floor may develop squeaks caused by deflection of the long edges of the sheets when walked upon.

In other words, with the joists spaced 16" on centers, it is necessary to cut pieces of 2"x4"s approximately 14⅜" long and the ends of these 2"x4"s must be nailed into the sides of the joists to provide nailing for the long edges of the plywood sheets. As the plywood is usually 4'-0" wide, it means a row of 2"x4" blocking must be run at right angles to the floor joists every 4'-0" apart to provide nailing for the long edges of the plywood sheets. This requires a lot of extra work—and at the present rate of wages costs a lot of money.

In buildings with regular spans, where an underlayment is to be provided, and where the long edges of the plywood sheets are not nailed, two carpenters working together should handle, fit, lay and nail 52 to 60 sheets (1,664 to 1,920 sq. ft.) of 4'-0"x8'-0" plywood, ⅝" to ¾" thick per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.9	$.....	$.....	$6.75	$6.08
Labor	0.3	.....	.....	5.00	1.50
Cost per 100 sq. ft.	1.2		$.....		$7.58
Cost per sq. ft.					.076

If 2"x4" wood blocking is required between the joists, as described above, and the plywood sheets must be nailed both longitudinally and crosswise, two carpenters working together should cut and nail blocks, and handle, fit, lay and nail 26 to 30 sheets of 4'-0"x8'-0" plywood (832 to 960 sq. ft.) $\frac{5}{8}$" to $\frac{3}{4}$" thick per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.8	$.....	$.....	$6.75	$12.15
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 sq. ft.	2.3		$.....		$14.65
Cost per sq. ft.					.147

Laying Plywood Decking for Panel and Girder Floor Systems.—Plywood decking for panel and girder floor construction should be 1" or $1\frac{1}{4}$" thick and laid with staggered joints. To minimize waste, inside dimensions of building should be laid out on a 4-ft. module, which also reduces cutting of panels to starters in every other row. In some localities, 4'x4' plywood panels are available as a stock size.

On large projects, where the work may be highly organized, a carpenter and 2 helpers should lay 4,500 to 4,700 sq. ft. of plywood decking per 8-hr. day, or enough for 3 to 4 average one-story houses, at the following labor cost per 1,000 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.75	$.....	$.....	$6.75	$11.82
Labor	3.50	.....	.....	5.00	17.50
Cost per 1,000 sq. ft.	5.25		$.....		$29.32
Cost per sq. ft.			.....		.029

For smaller jobs, where only 1 or 2 houses are involved, increase above costs about 25 percent to absorb lost motion in laying out work and getting started.

Where plywood decking is to be covered with linoleum or other resilient flooring, requiring a fairly smooth surface, a carpenter should spackle and sand joints, surface cracks and other imperfections at the rate of 200 sq. ft. per hr.

Laying Wood Sheathing on Pitch or Gable Roofs.—When laying roof sheathing on plain hip or gable roofs, a carpenter should lay 575 to 615 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	13.5	$.....	$.....	$6.75	$91.13
Labor	6.5	.....	.....	5.00	32.50
Cost 1,000 ft. b.m.	20.0		$.....		$123.63

On very steep roofs and roofs cut up with dormers, hips, valleys, etc., such as English type houses, etc., a carpenter will lay only 275 to 325 ft. of sheathing, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	26.5	$.....	$.....	$6.75	$178.88
Labor	7.5	.....	.....	5.00	37.50
Cost 1,000 ft. b.m.	34.0		$.....		$216.38

Labor Placing Sidewall Sheathing.—When sheathing sidewalls of frame buildings with 1"x6" or 1"x8" boards laid horizontally, a carpenter should handle and place 625 to 700 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	12	$.....	$.....	$6.75	$81.00
Labor	5	.....	.....	5.00	25.00
Cost 1,000 ft. b.m.	17		$.....		$106.00

Labor Placing Diagonal Sidewall Sheathing.—When sidewall sheathing is placed diagonally, it usually requires two carpenters working together—one at each end of the board. It also usually requires scaffolding the outside walls before the sheathing is placed, as the man at the top must have a scaffold from which to work.

On work of this class, a carpenter should place 450 to 525 ft. b.m. of 1"x6" or 1"x8" sheathing per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	16.5	$.....	$.....	$6.75	$111.38
Labor	5.5	.....	.....	5.00	27.50
Cost 1,000 ft. b.m.	22.0		$.....		$138.88

Placing Bevel and Drop Siding.—The labor cost of placing bevel or drop siding will vary with the class of work and the method of placing same.

On the less expensive type of construction it is customary to square only one end of the siding and the ends at the corners are left rough and are later covered with metal corner pieces. This is the cheapest method of placing siding. Metal corners

are extensively used in the South because the long summers and intense heat cause mitered wood corners to open up, making a very unsightly appearance.

On more expensive buildings, the door and window casings and corner boards are placed and then it is necessary to cut and fit each piece of siding between the corner boards or between the casings and corner boards. On work of this class two carpenters usually work together as it is necessary to square one end of the siding and then measure and cut each board separately to insure a snug fit. This increases labor costs considerably but makes a nicer appearing job than the metal corners.

This also applies where the siding is mitered at the corners. Two carpenters working together must measure and miter each piece of siding so that it will fit the adjoining corner—naturally this takes considerably more time than using metal corners but it makes a nicer appearing job.

The following quantities and costs are based on using ordinary brackets with plank scaffolding. If a more elaborate scaffold is required for placing siding, add extra for same.

Labor Placing Drop Siding

Measured Size Inches	Actual Size Inches	Class of Workmanship	Feet B.M. Placed per 8-Hr. Day	Carpenter Hours per 1000 Ft. B.M.
6.....	5½	Rough Ends	525-575	14.5*
6.....	5½	Fitted Ends	350-400	21.4
6.....	5½	Mitered Corners	285-325	26.3
8.....	7½	Rough Ends	600-650	12.8*
8.....	7½	Fitted Ends	415-460	18.2
8.....	7½	Mitered Corners	325-375	23.0

*Where an electric saw is used to square both ends of the siding before placing and leaving the exposed corners rough to be covered with metal corner pieces, deduct 1 to 1½ hours time per 1,000 ft. b. m. from the costs given above.

**Where an electric handsaw is used to square both ends of the siding before placing and leaving the exposed corners rough to be covered with metal corner pieces, deduct 1 to 1½ hours time per 1,000 ft. b.m. from the costs given on page 904.

Labor Placing Bevel Siding

Measured Size Inches	Actual Size Inches	Exposed to Weather Inches	Class of Workmanship	Feet B.M. Placed per 8-Hr. Day	Carpenter Hours per 1000 Ft. B.M.
4.....	3¼	2¾	Rough Ends	350-400	21.3**
4.....	3¼	2¾	Fitted Ends	240-285	30.5
4.....	3¼	2¾	Mitered Corners	200-240	36.3
5.....	4¼	3¾	Rough Ends	415-460	18.2**
5.....	4¼	3¾	Fitted Ends	285-330	25
5.....	4¼	3¾	Mitered Corners	240-285	30.5
6.....	5¼	4¾	Rough Ends	475-525	16*
6.....	5¼	4¾	Fitted Ends	325-375	23
6.....	5¼	4¾	Mitered Corners	265-310	28
8.....	7¼	6¾	Rough Ends	570-620	13.4**
8.....	7¼	6¾	Fitted Ends	375-415	20
8.....	7¼	6¾	Mitered Corners	300-350	24
10.....	9¼	8¾	Rough Ends	650-700	12**
10.....	9¼	8¾	Fitted Ends	440-480	17.5
10.....	9¼	8¾	Mitered Corners	375-425	20
12.....	11¼	10¾	Fitted Ends	475-525	16
12.....	11¼	10¾	Mitered Corners	400-450	19

* and ** See footnotes at bottom of page 903.

Placing Matched and Beaded Ceiling.—Matched and beaded ceiling is usually furnished 4″ and 6″ wide and ⅜″, ½″ and ¾″ thick.

Where the 4″ material is used for porch ceilings, overhang soffits, etc., a carpenter should place 285 to 325 ft. b.m., per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	26	$.....	$.....	$6.75	$175.50

The labor cost per square (100 sq. ft. surface) requiring 128 ft. of ceiling, b.m. should run as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	3.33	$.....	$.....	$6.75	$22.48

When placing 6″ wide matched and beaded ceiling, a carpenter should place 400 to 450 ft. of ceiling, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	18.8	$.....	$.....	$6.75	$126.90

The labor cost per square (100 sq. ft. surface) requiring 120 ft. of ceiling, b.m. should run as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	2.25	$.....	$.....	$6.75	$15.23

Placing Corner Boards, Fascia Boards, Etc.—When placing wood fascia boards, corner boards, etc., on houses, cottages,

etc., a carpenter should place 175 to 225 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	4	$.....	$.....	$6.75	$27.00
Cost per lin. ft.					.27

Placing Exterior Wood Cornices, Verge Boards, Etc.—When placing exterior wood cornices, verge boards, fascia, soffits, etc., consisting of 2 members, two carpenters working together should place 150 to 175 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	10	$.....	$.....	$6.75	$67.50
Cost per lin. ft.					.675

When the exterior cornices consist of 3 members (crown mold, bed mold, fascia, etc.), two carpenters working together should place 100 to 125 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	14.2	$.....	$.....	$6.75	$95.85
Cost per lin. ft.					.959

If a 4-member wood cornice is used, two carpenters working together should place 60 to 75 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	23.7	$.....	$.....	$6.75	$159.98
Cost per lin. ft.					1.599

The above quantities and costs do not include time blocking but for fascia boards, cornices, etc. An extra allowance should be made for all blocking required.

Porch Work

The labor placing porch work is a variable item owing to the vast difference in the style and construction of porches and the amount of detail involved.

The labor placing fascia, crown and bed mold, matched and beaded ceiling, etc., is given in the previous pages, while the labor cost of placing porch floors is given under "Wood Floors."

Placing Plain Porch Columns.—When placing plain square or turned porch columns, such as commonly used for rear porches and other inexpensive work, a carpenter should place one post in about ¾ hrs., at the following labor cost:

	Hours	Rate	Total	Rate	Total
Carpenter	0.75	$.....	$.....	$6.75	$5.06

Placing Porch Top and Bottom Rail and Balusters.—When placing wood top and bottom rail and wood balusters, such as used on front porches, a carpenter should complete 15 to 20 lin.

ft. of rail per 8-hr. day, at the following labor cost per lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.46	$.....	$.....	$6.75	$3.11

When placing top and bottom rails with open balusters or using matched and beaded ceiling, such as is often used for the cheaper grades of work, a carpenter should complete 35 to 45 lin. ft. of rail per 8-hr. day, at the following labor cost per lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.2	$.....	$.....	$6.75	$1.35

Framing and Erecting Exterior Wood Stairs for Rear Porches.—When framing and erecting outside wood stairs for rear porches on apartment buildings, etc., where the stringers are 2"x10" or 2"x12" lumber, with treads and risers nailed on the face of the stringers, it will require 18 to 22 hrs. carpenter time per flight of stairs.

This is for an ordinary stair having 14 to 18 risers extending from story to story, and the labor per flight should cost as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	20	$.....	$.....	$6.75	$135.00

If the stair consists of 2 short flights with an intermediate landing platform between stories it will require 12 to 13 hrs. carpenter time per flight or 24 to 26 hrs. per story, including platform, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Carpenter	25	$.....	$.....	$6.75	$168.75

Framing and Erecting Wood Stairs Having Winders.—Where the wood stairs to rear porches have 4 to 6 winders in each story height, figure 24 to 28 hrs. carpenter time, at the following labor cost per story:

	Hours	Rate	Total	Rate	Total
Carpenter	26	$.....	$.....	$6.75	$175.50

WOOD BLOCKING, FURRING AND GROUNDS

Placing Wood Furring Strips on Masonry Walls.—Where it is necessary to place wood furring strips on brick or tile walls before lathing and plastering, allowing the strips to follow the line of the walls without wedging or blocking out to make them straight or plumb, with the nails driven into dry joints in the brickwork, a carpenter should place 500 to 550 lin. ft. of furring per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$.....	$.....	$6.75	$10.13
Cost per lin. ft.					.101
Cost per Square (100 Sq. Ft.)					
Strips 12" centers	1.7	$.....	$.....	$6.75	$11.48
Strips 16" centers	1.3	.....	.....	6.75	8.78

First Grade Workmanship

Where it is necessary to plug the masonry walls and place all furring strips absolutely straight and plumb to produce a level surface to receive lath and plaster, a carpenter should plug walls and place 200 to 250 lin. ft. of strips per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	3.5	$.....	$.....	$6.75	$23.63
Cost per lin. ft.			.....		.236

Cost per Square (100 Sq. Ft.)

Strips 12″ centers	3.9	$.....	$.....	$6.75	$26.33
Strips 16″ centers	2.9	.....	.....	6.75	19.58

Placing Wood Grounds.—Where wood grounds are nailed direct to wood furring strips, door and window openings, etc., allowing them to follow the rough furring, partitions and wood bucks, without wedging or blocking to make them absolutely straight, a carpenter should place 540 to 590 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.4	$.....	$.....	$6.75	$9.45
Cost per lin. ft.			.....		.095

First Grade Workmanship

Where it is necessary to keep all wood grounds absolutely straight, plumb and level for the finish plaster and to receive the interior wood finish, and where it is necessary to plug the masonry walls with wood plugs to hold the nails, a carpenter should place 200 to 250 lin. ft. of grounds per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	3.5	$.....	$.....	$6.75	$23.63
Cost per lin. ft.			.....		.236

Wood Blocking and Grounds Around Window Openings.—Where the masonry walls are 12″ or more in thickness, requiring a wood jamb lining, a carpenter should place all necessary wood blocking and grounds for a window up to 4′-0″x6′-0″ in size in ¾ to 1¼ hr. at the following labor cost.:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$.....	$.....	$6.75	$6.75

Windows 4′-0″x7′-0″ to 5′-0″x8′-0″ in size will require 1⅛ to 1⅜ hrs. to place blocking and grounds, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	1.25	$.....	$.....	$6.75	$8.44

First Grade Workmanship

In the better class of buildings where all grounds must be absolutely straight and plumb and it is necessary to plug the

brick and tile walls for securing the grounds and blocking, a carpenter should complete one window up to 4'-0"x6-0" in size in 1¼ to 1¾ hrs. at the following labor cost:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$.....	$.....	$6.75	$10.13

A carpenter should plug walls, place blocking and grounds for one window 4'-0"x7'-0" to 5'-0"x8'-0" in 1½ to 2 hrs. at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	1.75	$.....	$.....	$6.75	$11.82

Wood Blocking for Cabinet and Case Bases.—A carpenter should locate, frame and set 115 to 135 ft. b.m. of 2"x4" or 2"x6" blocking for cabinet or case bases per 8-hr. day at the following labor cost per 1,000 ft. b.m.:

	Hours	Rate	Total	Rate	Total
Carpenter	64	$.....	$.....	$6.75	$432.00

Wood Furring Strips Over Wood Subfloors.—When placing 1"x2" or 2"x2" wood furring strips over wood subfloors to receive finish flooring, a carpenter should place 550 to 600 lin. ft. (without wedging or leveling) per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.4	$.....	$.....	$6.75	$9.45
Labor	0.3			5.00	1.50
Cost per 100 lin. ft.	1.7	.....	$.....		$10.95
Cost per lin. ft.					.110

Cost per Square (100 Sq. Ft.)

Strips 12" centers	1.9	$.....	$.....	$6.75	$12.83
Strips 16" centers	1.4	.....	.....	6.75	9.45

First Grade Workmanship

In the better class of buildings where the wood furring strips must be wedged up and blocked to produce an absolutely level surface to receive finish flooring, a carpenter should place 250 to 300 lin. ft. of furring strips per 8-hr. day, at the following cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	3.0	$.....	$.....	$6.75	$20.25
Labor	0.3	.....	.....	5.00	1.50
Cost 100 lin. ft.	3.3		$.....		$21.75
Cost per lin. ft.			.....		.218

Cost per Square (100 Sq. Ft.)

Strips 12" centers	3.6	$.....	$.....	$6.75	$24.30
Strips 16" centers	2.8	.....	.....	6.75	18.90

Placing Strip Deadening Felt and Wood Furring Strips Over Wood Subfloors.—Frequently a narrow strip of deadening felt ½"x3" is placed under the wood furring strips and both are nailed to the wood subfloor, as this provides better insulation and deadening than where the furring strips are nailed directly to the subfloor.

On work of this kind, a carpenter should place 425 to 475 lin. ft. of deadening felt and furring strips per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.8	$.....	$.....	$6.75	$12.15
Labor	0.4	.....	.....	5.00	2.00
Cost 100 lin. ft.	2.2		$.....		$14.15
Cost per lin. ft.			.....		.142
Cost per Square (100 Sq. Ft.)					
Strips 12" centers	2.4	$.....	$.....	$6.75	$16.20
Strips 16" centers	1.9	.....	.....	6.75	12.83

First Grade Workmanship

Where it is necessary to wedge and block up the strips to produce an absolutely level surface to receive the finish flooring, a carpenter should place 220 to 250 lin. ft. of deadening and furring strips per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	3.5	$.....	$.....	$6.75	$23.63
Labor	0.4	.....	.....	5.00	2.00
Cost 100 lin. ft.	3.9		$.....		$25.63
Cost per lin. ft.			.....		.256
Cost per Square (100 Sq. Ft.)					
Strips 12" centers	4.3	$.....	$.....	$6.75	$29.03
Strips 16" centers	3.3	.....	.....	6.75	22.28

Placing Deadening Quilt Over Rough Wood Floors.—Where deadening felt or quilt is laid over wood subfloors, a man should handle and lay 200 to 250 sq. ft. of felt an hr. at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	0.5	$.....	$.....	$5.00	$2.50
Cost per sq. ft.					.025

The above costs are based on deadening felts or quilts in rolls or sheets that can be laid on the rough floor and the furring strips placed directly over them.

Cost of Placing Deadening Felt and Wood Furring Strips Over 100 Sq. Ft. of Floor

Strips 12" on Centers—Ordinary Workmanship

	Hours	Rate	Total	Rate	Total
Carpenter	2.0	$.....	$.....	$6.75	$13.50
Labor	0.3	.....	.....	5.00	1.50
Cost 100 sq. ft.	2.3		$.....		$15.00
Cost per sq. ft.			.....		.150

Strips 16" on Centers—Ordinary Workmanship

	Hours	Rate	Total	Rate	Total
Carpenter	1.6	$.....	$.....	$6.75	$10.80
Labor	0.3	.....	.....	5.00	1.50
Cost 100 sq. ft.	1.9		$.....		$12.30
Cost per sq. ft.			.....		.123

Strips 12" on Centers—First Grade Workmanship

	Hours	Rate	Total	Rate	Total
Carpenter	3.8	$.....	$.....	$6.75	$25.65
Labor	0.3	.....	.....	5.00	1.50
Cost 100 sq. ft.	4.1		.....		$27.15
Cost per sq. ft.			.....		.271

Strips 16" on Centers—First Grade Workmanship

	Hours	Rate	Total	Rate	Total
Carpenter	3.0	$.....	$.....	$6.75	$20.25
Labor	0.3	.....	.....	5.00	1.50
Cost 100 sq. ft.	3.3		$.....		$21.75
Cost per sq. ft.			.....		.218

Placing Wood Floor Sleepers.—When placing 2"x3" or 2"x4" wood floor screeds or sleepers over rough tile or concrete floors, to receive finish flooring, a carpenter should place 225 to 275 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	3.2	$.....	$.....	$6.75	$21.60
Labor	0.8	.....	.....	5.00	4.00
Cost 100 lin. ft.	4.0		$.....		$25.60
Cost per lin. ft.			.....		.256

First Grade Workmanship

In the better class of buildings, 2"x3" or 2"x4" beveled floor sleepers are placed over the rough concrete floors and wedged or blocked up to provide a perfectly level surface to receive the finish flooring.

The screeds are usually held in place by metal clips placed in the rough concrete, or anchored with special purpose nails.

On work of this class, a carpenter should place, wedge-up and level 130 to 170 lin. ft. of sleepers per 8-hr. day, including setting sleeper clips, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Labor
Carpenter	5.3	$.....	$.....	$6.75	$35.78
Labor	0.8			5.00	4.00
Cost per 100 lin. ft.	6.1		$.....		$39.78
Cost per lin. ft.			.....		.40

Lumber Required for Wood Door Bucks of 2"x4" Lumber

Size of Opening	Lin. Ft. of Lumber Req'd.	Board Feet of Lumber Req'd.	With Transom Add Lineal Ft.	Board Ft.
2'—0"x4'—0"	12	8	6'—0"	4
2'—0"x4'—6"	12	8	6'—0"	4
2'—0"x5'—0"	13½	9	6'—0"	4
2'—6"x4'—0"	12	8	6'—6"	4⅓
2'—6"x4'—6"	13	8⅔	6'—6"	4⅓
2'—6"x5'—0"	14	9⅓	6'—6"	4⅓
2'—6"x5'—6"	15	10	6'—6"	4⅓
2'—6"x6'—0"	16	10⅔	6'—6"	4⅓
2'—6"x6'—6"	17	11⅓	6'—6"	4⅓
2'—6"x7'—0"	18	12	6'—6"	4⅓
2'—8"x6'—8"	17	11⅓	7'—0"	4⅔
2'—8"x7'—0"	18	12	7'—0"	4⅔
3'—0"x7'—0"	19	12⅔	7'—0"	4⅔
3'—6"x7'—0"	19	12⅔	7'—6"	5
4'—0"x7'—0"	20	13⅓	8'—0"	5⅓
5'—0"x7'—0"	21	14	9'—0"	6
6'—0"x7'—0"	22	14⅔	10'—0"	6⅔
7'—0"x7'—0"	24	16	11'—0"	7⅓
3'—6"x7'—6"	20	13⅓	7'—6"	5
4'—0"x7'—6"	20	13⅓	8'—0"	5⅓
4'—6"x7'—6"	21	14	8'—6"	5⅔
5'—0"x7'—6"	21	14	9'—0"	6
6'—0"x7'—6"	22	14⅔	10'—0"	6⅔
7'—0"x7'—6"	24	16	11'—0"	7⅓
3'—6"x8'—0"	21	14	7'—6"	5
4'—0"x8'—0"	22	14⅔	8'—0"	5⅓
5'—0"x8'—0"	22	14⅔	9'—0"	6
6'—0"x8'—0"	23	15⅓	10'—0"	6⅓
7'—0"x8'—0"	24	16	11'—0"	7⅓
8'—0"x8'—0"	25	16⅔	12'—0"	8
9'—0"x9'—0"	28	18⅔	9'—0"	6

The lumber quantities given in the table are estimated i· lengths that cut with the least waste.

Lumber Required for Wood Door Bucks of 2"x6" Lumber

Size of Opening	Lin. Ft. of Lumber Req'd.	Board Ft. of Lumber Req'd.	With Transom Add Lineal Ft.	Board Ft.
2'—0"x4'—0"	12	12	6'—0"	6
2'—0"x4'—6"	12	12	6'—0"	6
2'—0"x5'—0"	13½	13½	6'—0"	6
2'—6"x4'—0"	12	12	6'—6"	6½
2'—6"x4'—6"	13	13	6'—6"	6½
2'—6"x5'—0"	14	14	6'—6"	6½
2'—6"x5'—6"	15	15	6'—6"	6½
2'—6"x6'—0"	16	16	6'—6"	6½
2'—6"x6'—6"	17	17	6'—6"	6½
2'—6"x7'—0"	18	18	6'—6"	6½
2'—8"x6'—8"	17	17	7'—0"	7
3'—0"x7'—0"	19	19	7'—0"	7
3'—6"x7'—0"	19	19	7'—6"	7½
4'—0"x7'—0"	20	20	8'—0"	8
5'—0"x7'—0"	21	21	9'—0"	9
6'—0"x7'—0"	22	22	10'—0"	10
7'—0"x7'—0"	24	24	11'—0"	11
3'—6"x7'—6"	20	20	7'—6"	7½
4'—0"x7'—6"	20	20	8'—0"	8
4'—6"x7'—6"	21	21	8'—6"	8½
5'—0"x7'—6"	21	21	9'—0"	9
6'—0"x7'—6"	22	22	10'—0"	10
7'—0"x7'—6"	24	24	11'—0"	11
3'—6"x8'—0"	21	21	7'—6"	7½
4'—0"x8'—0"	22	22	8'—0"	8
5'—0"x8'—0"	22	22	9'—0"	9
6'—0"x8'—0"	23	23	10'—0"	10
7'—0"x8'—0"	24	24	11'—0"	11
8'—0"x8'—0"	25	25	12'—0"	12
9'—0"x9'—0"	28	28	9'—0"	9

Wood Door Bucks

Wood door bucks are made from 2"x4" or 2"x6" lumber, depending upon the thickness of the partition in which they are to be used.

Considerable saving may be affected by using bucks made from 2"x6" lumber, having the back grooved out the thickness of the partition and ½" to ¾" deep. For a 5½" finished partition, this allows for a 4" tile or gypsum partition block and 1½" for plaster on both sides of the partition. The partition tile fit into the groove in the wood buck and the ¾" extension on each side provides a ground for nailing the trim.

The mills furnishing the lumber usually charge $9.50 to $12.00 per 1,000 ft. b.m. for grooving the backs of 2"x6"s.

The lumber quantities given above are estimated in lengths that cut with the least waste.

Labor Making Rough Door Bucks.—A carpenter should make and brace a rough door buck for an opening up to 3'-0"x7'-0" in about 1-hr. If the door has a transom, add ½-hr. carpenter time.

When making rough door bucks for door openings 5'-0"x7'-0" to 6'-0"x9'-0", a carpenter should make and brace one door buck in 1¼ to 1½ hrs. If the door has a transom, add ½ to ¾-hr. carpenter time.

Rough Wood Bucks for Borrowed Lights.—When making rough wood bucks for borrowed lights, a carpenter should make and brace one buck for an average size opening in 1 to 1½ hrs.

Setting Rough Door Bucks.—After the rough door buck has been made, a carpenter should set, plumb and brace one door buck for an opening up to 3'-0"x9'-0" in about 1 to 1¼ hr.

For double doors requiring an opening from 5'-0"x7'-0" to 6'-0"x9'-0", a carpenter should set, plumb and brace one large door buck in 1¼ to 1½ hrs.

CAULKING DOOR AND WINDOW FRAMES

Caulking Door and Window Frames with Oakum.—When the space between the door and window frames and masonry walls are caulked with oakum, an experienced man should caulk 340 to 400 lin. ft. of opening per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Caulker	2.1	$.....	$.....	$6.75	$14.18
Cost per lin. ft.					.142
Size of Opening					
Up to 3'-0"x5'-0"	0.33	.....	.....	6.75	2.23
3'-6"x5'-6" to 3'-0"x6'-0"	.38	.....	.....	6.75	2.57
3'-6"x6'-6" to 3'-0"x7'-0"	.40	.....	.....	6.75	2.70
3'-6"x7'-6" to 4'-0"x8'-0"	.50	.....	.....	6.75	3.38
4'-6"x8'-6" to 5'-0"x9'-0"	.60	.....	.....	6.75	4.05

The above quantities and costs are based on openings which are easily accessible to the caulker. For inaccessible openings or where necessary to build special scaffold, add accordingly.

Caulking Doors and Windows Using Mastic Caulking Compound.—The quantity of mastic caulking compound required for caulking around doors and windows will vary with the size of the openings and with the manner in which the operator applie

the material. If the material is forced well back into the opening more material will be used than if a thin strip is laid on top. The proper method is to force as much material as possible into the opening. Deep openings should be filled with oakum to within ¾" of face.

General experience would indicate that one gallon will caulk approximately 180 to 240 lin. ft. of average sized opening. However, on large openings, where a pressure gun is used with a ½" nozzle, one gallon will caulk about 100 lin. ft.; using a ⅜" nozzle, with average size openings, one gallon should caulk about 150 lin. ft. Using a ¼" nozzle, one gallon should caulk 300 to 350 lin. ft. Estimate an average of 150 lin. ft. per gal.

For caulking around doors and windows nothing smaller than ⅜" nozzle should be used, preferrably ½", or life of job is endangered.

Mastic caulking compound costs from $4.00 to $6.50 per gal. depending upon quality and quantity purchased.

Labor Caulking Using a Pressure Gun.—Figuring an average opening as containing 18 to 20 lin. ft. a workman should caulk 28 to 32 openings per 8-hr. day, unless they are quite inaccessible. Where openings are quite accessible, he should do more.

Where it is possible for two men to caulk and a helper to fill guns, the two caulkers should average 50 to 55 openings, each per day. This is based on an average size window, 4'-0"x6'-0", requiring approximately 20 lin. ft. of caulking.

Based on one man working alone, the cost of caulking one average size opening (about 20 lin. ft.) should cost as follows:

	Hours	Rate	Total	Rate	Total
⅛-gal. caulking compound		$.....	$.....	$6.00	$0.75
Caulker	0.3	.....	.....	6.75	2.03
Cost per opening.....	0.3		$.....		$2.78
Cost per lin. ft.					1.39

The above is based on using a ⅜" nozzle with average size openings. If the openings around doors and windows are larger or smaller than ⅜", amount of caulking compound should be increased or decreased accordingly.

If two caulkers are working together with a helper to keep guns filled, decrease labor costs as given above.

Good jobs require a clean joint and caulking must be kept warm in cold weather. Where old caulking has failed it should be removed. Where mortar has cracked or come loose it should be removed. All such cleaning or preparatory costs should be added.

Fireproofing Wood.—Where framing lumber and timbers are chemically treated to fireproof the wood, the cost of this treatment practically doubles the cost of the untreated wood.

HEAVY MILL CONSTRUCTION

The quantities and costs included under this classification cover all types of heavy constructed mill, warehouse and factory buildings, etc.

Framing and Erecting Heavy Wood Columns or Posts.—The labor cost of erecting and framing heavy wood columns or posts, 10″x10″ or larger, will vary according to the number of operations necessary, such as chamfering corners, cutting out and framing for post caps and bases, boring holes through the center, and upon the distance the posts must be hoisted before placing.

On the average mill constructed job requiring 10″x10″ or 12″x12″ posts 10′-0″ to 16′-0″ long, it will require 3½ to 4 hrs. time to chamfer corners, frame for bases and caps, and erect each column, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Carpenter	3.7	$.....	$.....	$6.75	$24.98
Labor	0.5	.....	.....	5.00	2.50
Cost per column	4.2		$.....		$27.48

If hoisted above the second floor, add ½-hr. labor time per column.

It is more difficult to estimate the cost of this work by the 1,000 ft. of lumber, b.m. as it costs just as much to chamfer the 4 corners and frame for post caps and bases for an 8″x8″ as a 12″x12″ column, while the former contains less than half as much lumber per lin. ft. as the latter. The following costs are based on an average 10″x10″-12′-0″ timber and should be increased or reduced accordingly for larger or smaller timbers.

Based on a 10″x10″-12′-0″ column, a carpenter should chamfer corners, frame for post caps and bases, handle and erect 200 to 250 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	35	$.....	$.....	$6.75	$236.25
Labor	8	.....	.....	5.00	40.00
Cost 1,000 ft. b.m.	43		$.....		$276.25

Rounding Corners on Large Timbers.—Where the corners of wood columns, beams or girders must be rounded to a small radius, the yards or mills furnishing the lumber usually charge $15.00 to $20.00 per 1,000 ft. b.m. for performing this work.

Boring Holes Through Center of Large Timbers.—Where the wood columns or posts have a hole bored through the center for their entire length, the yard or mill furnishing the lumber usually charges $25.00 to $30.00 per 1,000 ft. b.m. for boring these holes.

Framing and Erecting Heavy Wood Beams and Girders for First Floor.—The labor cost of framing and erecting heavy wood beams and girders will vary according to the amount of framing necessary and the method used in placing them; i.e., whether they set on top of the wood columns or whether it is necessary to frame for post caps, stirrups, etc.

Placing heavy beams and girders for the first floor of a building does not require as much labor as for the upper floors because the timbers can be rolled to the place they are to be used without hoisting.

Where heavy wood girders are set on concrete or masonry piers without framing for post caps, joist hangers, etc., a carpenter should frame and erect 1,000 to 1,250 ft. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	7	$.....	$.....	$6.75	$47.25
Labor	7	.....	.....	5.00	35.00
Cost 1,000 ft. b.m.	14		$.....		$82.25

Where necessary to frame for post caps and bases, stirrups, etc., a carpenter should frame and erect 500 to 600 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	14.5	$.....	$.....	$6.75	$97.88
Labor	7.0	.....	.....	5.00	35.00
Cost 1,000 ft. b.m.	21.5		$.....		$132.88

Framing and Erecting Heavy Wood Girders Above First Floor.—Where heavy wood girders must be hoisted above the first floor, using a timber hoist or derrick, the carpenter time framing and placing the timbers will remain practically the same but the labor time handling, hoisting and skidding the timbers into place will be increased.

On work of this kind, a carpenter should frame and erect 450 to 550 ft. of lumber, b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	16	$.....	$.....	$6.75	$108.00
Labor	10	$.....	.....	5.00	50.00
Cost 1,000 ft. b.m.	26		$.....		$158.00

Framing and Erecting Heavy Wood Joists.—When placing heavy wood joists 4"x12" or 4"x16" in size, where the joists set on top of wood girders or in iron stirrups, a carpenter should frame and erect 1,000 to 1,200 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	7.3	$.....	$.....	$6.75	$49.28
Labor	3.5	.....	.....	5.00	17.50
Cost 1,000 ft. b.m.	10.8		$.....		$66.78

Where smaller joists are used, ranging from 3"x10" to 4"x10" in size, a carpenter should frame and erect 800 to 1,000 ft. b.m. per 8-hr. day, at the following labor cost per 1,000 ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	9	$.....	$.....	$6.75	$60.75
Labor	4	.....	.....	5.00	20.00
Cost 1,000 ft. b.m.	13		$.....		$80.75

Framing and Placing Oak Bumpers at Edges of Loading Docks.—Oak timbers, varying from 4"x6" to 12"x12", are usually called for at loading dock edges. The timbers generally are secured to the edge of the dock slab by bolts set in the concrete or with cinch anchors.

With bolts already set in place, a carpenter should lay out, drill and countersink holes and secure in place 150 to 175 ft. b.m. of oak bumper per 8-hr. day at the following labor cost per 1,000 ft. b.m.:

	Hours	Rate	Total	Rate	Total
Carpenter	48	$.....	$.....	$6.75	$324.00
Labor	24	.....	.....	5.00	120.00
Cost 1,000 ft. b.m.	72		$.....		$444.00

A carpenter should locate, set and secure in place in the slab edge or wall form about 25 anchor bolts per 8-hr. day at the following labor cost per bolt:

	Hours	Rate	Total	Rate	Total
Carpenter	0.3	$.....	$.....	$6.75	$2.03

Laying 2"x6" or 3"x6" Tongue and Groove Timber Subfloors or Roof Sheathing.—When laying 2"x6" or 3"x6" tongue and groove flooring or roof decking in large areas without much cutting and fitting, a carpenter should lay 800 to 1,000 ft. b.m. per 8-hr. day at the following labor cost per 1,000 ft.

	Hours	Rate	Total	Rate	Total
Carpenter	8.9	$.....	$.....	$6.75	$60.08
Labor	6.0	$.....	$.....	5.00	30.00
Cost per 1,000 ft. b.m.	14.9		$.....		$90.08

If tongue and groove flooring or roof sheathing is laid in small spaces requiring considerable cutting and fitting around openings, stair wells, elevator shafts, skylights, etc., a carpenter should lay 700 to 800 ft. b.m. per 8-hr. day at the following labor cost per 1,000 ft.

	Hours	Rate	Total	Rate	Total
Carpenter	10.6	$.....	$.....	$6.75	$71.55
Labor	6.0	$.....	$.....	5.00	30.00
Cost per 1,000 ft. b.m.	16.6		$.....		$101.55

LAMINATED WOOD FLOORS

Laminated wood floors consisting of 2" or 3" plank set on edge and spiked together, are used where a floor is desired, capable of carrying heavy loads or supporting heavy machinery with a minimum amount of vibration.

Sometimes the floors are designed to use certain length plank reaching from bearing to bearing while on others they are spiked together with broken joints, regardless of bearing.

Quantity of Lumber Required for Laminated Wood Floors

Measured Size Inches	Finished Thickness Inches	Add for Waste Per Cent	To Obtain Quantity of Lumber Required Multiply Area by	No. Feet Lumber Per 100 Square Feet of Surface
2x 4	1⅝	23	4.90	490 ft. or 74 pcs.
2x 6	1⅝	23	7.40	740 ft. or 74 pcs.
2x 8	1⅝	23	9.84	984 ft. or 74 pcs.
2x10	1⅝	23	12.30	1230 ft. or 74 pcs.
2x12	1⅝	23	14.76	1476 ft. or 74 pcs.
2x14	1⅝	23	17.22	1722 ft. or 74 pcs.
3x 6	2¾	10	6.60	660 ft. or 44 pcs.
3x 8	2¾	10	8.80	880 ft. or 44 pcs.
3x10	2¾	10	11.10	1110 ft. or 44 pcs.
3x12	2¾	10	13.20	1320 ft. or 44 pcs.
3x14	2¾	10	15.40	1540 ft. or 44 pcs.
4x 6	3¾	7	6.42	642 ft. or 32 pcs.
4x 8	3¾	7	8.56	856 ft. or 32 pcs.
4x10	3¾	7	10.70	1070 ft. or 32 pcs.
4x12	3¾	7	12.84	1284 ft. or 32 pcs.

The above quantities do not include any allowance for waste due to end matching, but are based on spans taking lumber of even lengths or laying flooring with broken joints.

Nails Required for 100 Sq. Ft. of 2" Laminated Flooring

Size Spikes	Distance Spikes Are Spaced Apart: 12 Inches No. Spikes	12 Inches No. Lbs.	16 Inches No. Spikes	16 Inches No. Lbs.	20 Inches No. Spikes	20 Inches No. Lbs.	24 Inches No. Spikes	24 Inches No. Lbs.	30 Inches No. Spikes	30 Inches No. Lbs.
16d	740	15	600	12¼	518	10½	450	9¼	370	7½
20d	740	24	600	19¼	518	16¾	450	14½	370	12
30d	740	31	600	25	518	21½	450	18¾	370	15½
40d	740	41	600	33¼	518	28¾	450	25	370	20½
50d	740	53	600	43	518	37	450	32	370	26½
60d	740	67	600	55	518	47	450	41	370	33¾

Nails Required for 100 Sq. Ft. of 3" Laminated Flooring

Size Spikes	Distance Spikes Are Spaced Apart: 12 Inches No. Spikes	12 Inches No. Lbs.	16 Inches No. Spikes	16 Inches No. Lbs.	20 Inches No. Spikes	20 Inches No. Lbs.	24 Inches No. Spikes	24 Inches No. Lbs.	30 Inches No. Spikes	30 Inches No. Lbs.
16d	440	9	352	7¼	308	6¼	264	5½	220	4½
20d	440	14¼	352	11½	308	10	264	8½	220	7
30d	440	18½	352	14¾	308	12¾	264	11	220	9¼
40d	440	24½	352	19½	308	17	264	14¾	220	12¼
50d	440	31½	352	25¼	308	22	264	18¾	220	15¾
60d	440	40	352	32	308	28	264	24	220	20

Nails Required for 100 Sq. Ft. of 4" Laminated Flooring

Size Spikes	Distance Spikes Are Spaced Apart: 12 Inches No. Spikes	12 Inches No. Lbs.	16 Inches No. Spikes	16 Inches No. Lbs.	20 Inches No. Spikes	20 Inches No. Lbs.	24 Inches No. Spikes	24 Inches No. Lbs.	30 Inches No. Spikes	30 Inches No. Lbs.
30d	320	13½	256	10¾	224	9½	192	8	160	6¾
40d	320	17¾	256	14¼	224	12½	192	10¾	160	9
50d	320	23	256	18¼	224	16	192	13¾	160	11½
60d	320	29	256	23¼	224	20½	192	17½	160	14½

Labor Costs on Half Timber Work.—The following costs on half timber work are taken from a college building.

The timber was white oak 3-in. thick, 10-in. and 11-in. wide and various lengths to meet the requirements of the job.

Nothing was done to the face of the timber and it was left just as received. The backs of all timbers were beveled, the thickness remaining 3-in. A shop was set up on the job where the timbers were cut, beveled and fit ready for erection.

There were 14,500 ft. b.m. of lumber used in this half-timber work and the labor cost per 1,000 ft. b.m. was as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	66.3	$.....	$.....	$6.75	$447.53
Labor helping	12.0	.....	.....	5.00	60.00
Cost per 1,000 ft. b.m.	78.3		$.....		$507.53

Half Timber Work on a College Building

After the timbers were cut, beveled and fit in the shop, the labor cost of placing and bracing the timbers in the building was as follows per 1,000 ft. b.m.:

	Hours	Rate	Total	Rate	Total
Carpenter	41.5	$.....	$.....	$6.75	$280.13
Labor helping	2.2	.....	.....	5.00	11.00
Cost per 1,000 ft. b.m...	43.7		$.....		$291.13

WOOD SHINGLES

The labor cost of laying wood shingles will vary with the type of roof, whether a plain gable roof, a steep roof or one cut up with gables, dormers, etc. Also with the manner in which they are laid, whether with regular butts, irregular or staggered butts, or thatched butts.

The costs given on the following pages are based on the actual number of shingles a man will lay per day and not upon the number of squares covered, as this will vary with the spacing of the shingles. It does not make any particular difference to the shingler whether the shingles are laid 4", 4½" or 5" to the weather, as he will lay practically the same number either way.

It does make considerable difference in the number of sq. ft. of surface covered, which will vary from 10 to 40%.

The number of shingles laid will vary with the ability of the workman and the class of work, as ordinary carpenters will not lay as many shingles as carpenters who specialize in shingle laying. On the other hand, experienced shinglers usually demand a higher wage rate than ordinary carpenters.

Some carpenters claim to be able to lay 16 bundles, (3,200 shingles) per 8-hr. day, but this is unusual and is generally found only on the cheapest grade of work where only one nail is driven into each shingle instead of two that are necessary to secure a workmanlike job.

Estimating the Quantity of Wood Shingles.—Ordinary wood shingles are furnished in random widths, but 1,000 shingles are equivalent to 1,000 shingles 4″ wide.

Dimension shingles are sawed to a uniform width, being either 4″, 5″ or 6″ wide.

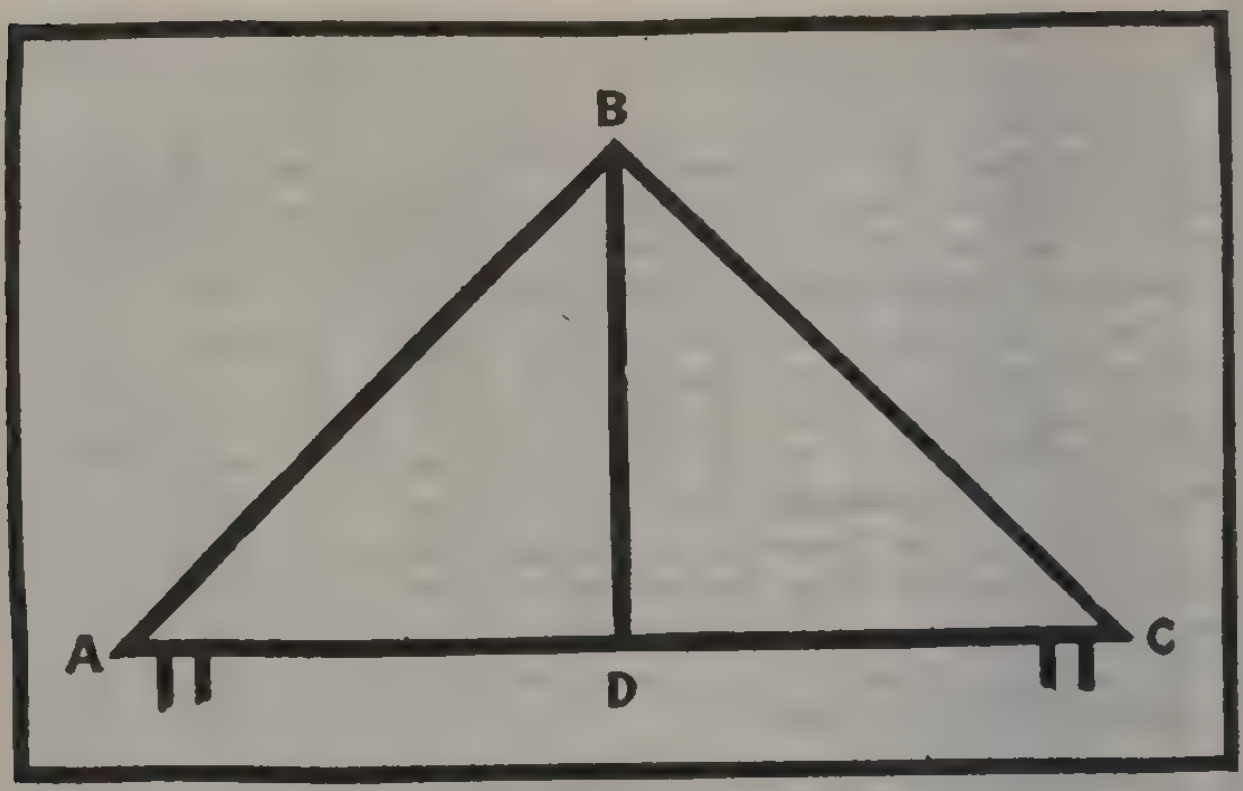
Wood shingles are usually sold by the square based on sufficient shingles to lay 100 sq. ft. of surface, when laid 5″ to the weather, 4-bundles to the square.

When estimating the quantity of ordinary wood shingles required to cover any roof, bear in mind that the distance the shingles are laid to the weather makes considerable difference in the actual quantity required.

There are 144 sq. in. in 1 sq. ft. and an ordinary shingle is 4″ wide. When laid with 4″ exposed to the weather, each shingle covers 16 sq. in or it requires 9 shingles per sq. ft. of surface. There are 100 sq. ft. in a square. $100 \times 9 = 900$, and allowing 10% to cover the double row of shingles at the eaves, waste in cutting, narrow shingles, etc., it will require 990 shingles (5 bundles) per 100 sq. ft. of surface.

Number of Shingles and Quantity of Nails Required Per 100 Sq. Ft. of Surface

Distance Laid to Weather	Area Covered by One Shingle Sq. In.	Add for Waste Per Cent	Actual No. per Square Without Waste	Number per Square With Waste	No. of 4-Square Bundles Required	Pounds 3d Nails Req'd
4 ″	16	10	900	990	5.0	3.2
4¼″	17	10	850	935	4.7	2.8
4½″	18	10	800	880	4.4	2.5
5 ″	20	10	720	792	4.0	2.0
5½″	22	10	655	720	3.6	1.6
6 ″	24	10	600	660	3.3	1.5



How to Apply Shingles for Different Roof Slopes.—Roof pitches are computed in fractions, such as $\frac{1}{8}$, $\frac{1}{3}$, $\frac{1}{2}$ pitch. In this cross-section, the steepness of distances AB and BC constitutes pitch. Distance AC, extending from one eave-line to the other, is known as the span. One-half of this span, distance AD or DC, is called the run, and distance BD is called the rise. The relationship of the rise to run obviously affects the slope of AB or BD; in fact, roof pitches are computed from the ratio of rise to run. Therefore, the first step is to determine length of the run (AD or DC) and the rise (BD).

Wood shingles are manufactured in three lengths—16-inch, 18-inch and 24-inch. The standard weather exposure (portion of shingle exposed to weather on roof) for 16-inch shingles is 5″, for 18-inch shingles it is 5½″, and for 24-inch shingles it is 7½″. These standard exposures are recommended on all roofs of $\frac{1}{4}$ pitch and steeper (6″ rise in 12″ run). On flatter roof slopes, the weather exposure should be reduced to 3¾″ for 16-inch shingles, 4¼″ for 18-inch shingles, and 5¾″ for 24-inch.

This diagram shows at a glance, the weather exposure to be used for various roof pitches. For example, if a roof has a rise of 8″ in a run of 12″, it can be seen that this is $\frac{1}{3}$ pitch and that an exposure of either 5″, 5½″ or 7½″ should be employed, depending upon the length of the shingles used.

Refer to the first part of this Chapter for table headed "Lengths of Common, Hip, and Valley Rafters Per 12 Inches of

Labor Laying One Square (100 Sq. Ft.) Wood Shingles

Class of Work	Mechanic	Number Laid per 8-Hr. Day	Distance Shingles are Laid to Weather					
			4"†	4¼"	4½"	5"	5½"	6"
Plain Gable or Hip Roofs	Carpenter	2,000–2,200	3.8	3.6	3.4	3.0	2.8	2.5
	Shingler	2,750–3,000	2.8	2.6	2.5	2.3	2.0	1.9
Difficult Gable Roofs, cut up with gables, dormers, hips, valleys, etc.	Carpenter	1,700–1,900	4.5	4.2	4.0	3.6	3.3	3.0
	Shingler	2,200–2,500	3.4	3.2	3.0	2.7	2.5	2.3
Difficult Hip Roofs, Steep English Roofs, hips, valleys, etc.	Carpenter	1,300–1,500	5.7	5.4	5.1	4.6	4.2	3.8
	Shingler	2,000–2,200	3.8	3.6	3.4	3.0	2.8	2.5
Shingles Laid Irregularly or with Staggered Butts on Plain Roofs.	Carpenter	1,700–1,900	4.5	4.2	4.0	3.6	3.3	3.0
	Shingler	2,400–2,700	3.1	3.0	2.8	2.5	2.3	2.1
Shingles Laid Irregularly or with Staggered Butts on Difficult Constructed Roofs.	Carpenter	1,100–1,300	6.7	6.3	6.0	5.4	4.9	4.5
	Shingler	1,600–1,800	4.7	4.5	4.2	3.8	3.4	3.1
Shingles with Thatched Butts.*	Shingler	800–1,000	8.9	8.4	8.0	7.1	6.5	6.0
Plain Sidewalls.	Carpenter	1,300–1,500	5.7	5.4	5.1	4.6	4.2	3.8
	Shingler	1,700–1,900	4.5	4.3	4.0	3.6	3.3	3.0
Difficult Sidewalls, having bays, windows, breaks, etc.	Carpenter	1,100–1,250	6.8	6.4	6.0	5.4	5.0	4.5
	Shingler	1,400–1,650	5.2	5.0	4.6	4.2	3.8	3.5

To obtain number of bundles of shingles required, divide number of shingles as given above by 200, and the result will be the number of bundles required, i.e. 2,200 shingles÷200 equals 11 bundles; 1,000÷200=5 bundles; 800÷200=4 bundles, etc.

*Shingles with thatched butts require 25% more shingles than when laid regularly.

†Use 4" column for carpenter or shingler time per 1,000 shingles. (5 bundles).

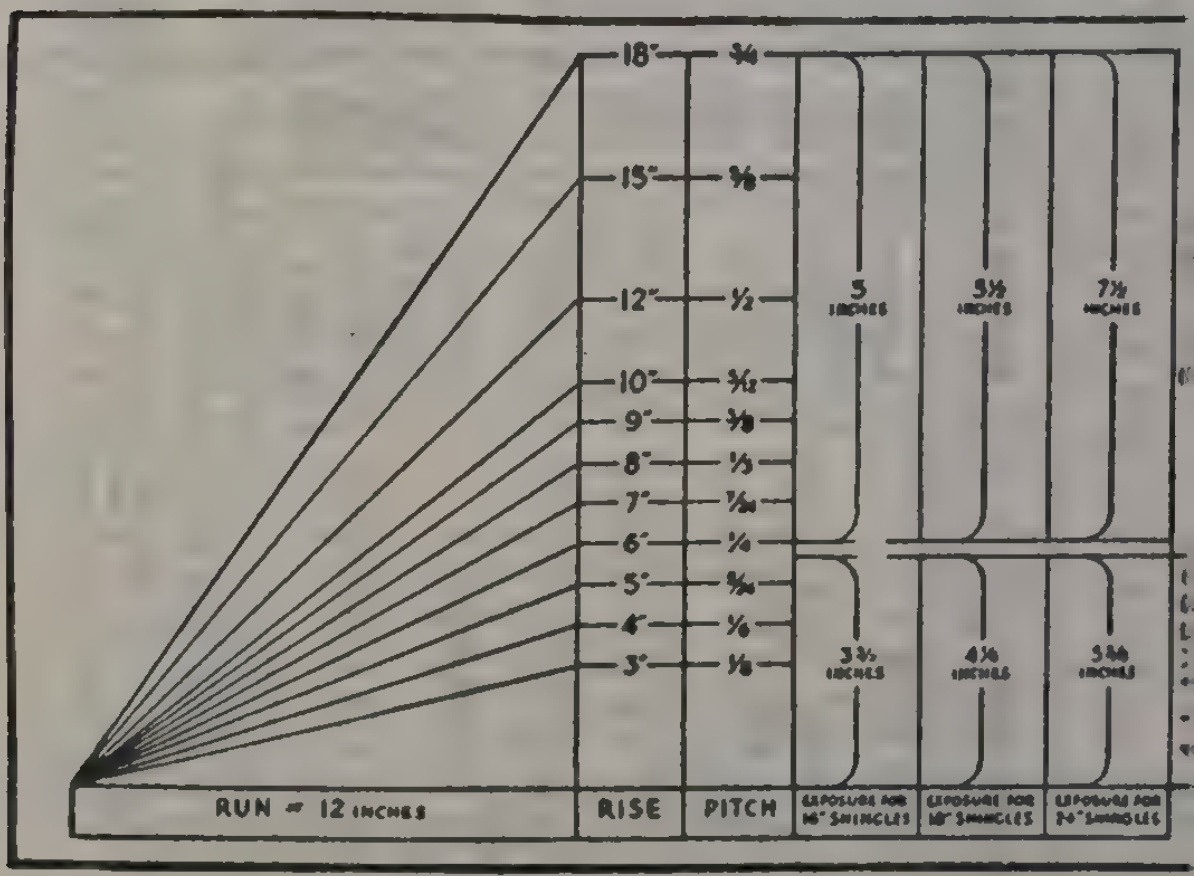
The above table is based on using 2 nails to each shingle and 10 per cent waste.

Run" and "To Obtain Area of Roofs for Any Pitch" to obta the number of square feet of roof surface to be covered wi shingles at varying roof pitch.

The use of asphalt shingles is more common in mass produc and moderate priced housing. Complete estimating data asphalt shingles is given under the chapter on "Roofing, Co rugated Asbestos and Metal Roofing and Siding."

Wood shingles can be obtained in three grades. Approxima prices per square f.o.b the mill in Seattle, Wash. for 16" (1 pounds) red cedar shingles are #1-$14.00, #2-$11.50, and #3- "clear" $8.20. For 18" shingles (158 pounds), #1-$14.85, #2-$11.8 and #3-$8.80. For 24" shingles (192 pounds) #1-$18.00, #2-$11.8 and #3-$9.40.

Split red cedar shakes are considerably heavier. Shakes 2 long and from ½" to ¾" thick weighing approximately 280 pounc cost $15.35 per square f.o.b. mill. ¾" to 1¼" thick units weighi approximately 350 pounds per square cost $15.85 f.o.b. mill.



WOOD ROOF TRUSSES

Wood roof trusses are used in buildings where clear floor spac is a requirement and the width of the building exceeds the ecc nomical span of roof joists. Some of the advantages of trusse

oof construction are fast erection, unobstructed weather pro-ected space available sooner, simplified installation of ceiling, oor, mechanical and electrical systems, use of non-load-bearing noveable partitions, etc.

Wood roof trusses are used for spans as short as 25′-0″, and nay be used up to 200′-0″.

Wood roof trusses are widely used in garages, factories, hang-rs, gymnasiums, auditoriums, bowling alleys, dance halls, super-narkets, and other structures of this type.

When using wood roof trusses, it is common practice to span he shorter dimension of the building. This may be accomplished vith any of several truss designs available, such as bowstring, rescent, Belgian, flattop, super-bow, scissors and Gothic. The ype of truss is dependent upon the degree in which economy is mphasized, the use of the building and the general architectural ffect desired.

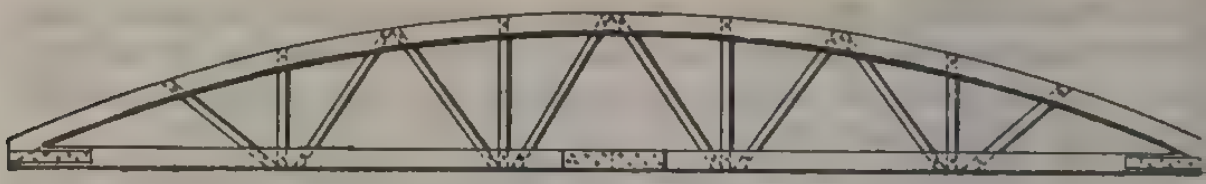
Prices on roof trusses are governed by the following condi-ions:

1. Cost of material and labor.
2. Loading conditions and spacing.
3. Difficulties of erection.
4. Requirements of local building ordinances.

The fourth condition causes the price of trusses to vary con-iderably in different parts of the country since some cities require nly a 25 lb. live load while others require a 50 lb. live load, thus ecessitating heavier construction.

Spacing of wood roof trusses is usually 16′-0″ to 20′-0″ on enters, but the 16′-0″ spacing is more generally used. The spacing f trussed rafters which support the roof sheathing directly (in-tead of with purlins as is the case where trusses are used) is sually 2′-0″. Where roof loads are light and the installation f a ceiling is not required, spacings of 4′-0″ and 5′-0″ can be dvantageous. Where snow loads are especially heavy, spacings f 16″ and even 12″ have been used.

The prices given on the following pages are approximate only nd it is advisable to obtain definite prices from the manufac-urers for either trusses delivered at the building site or installed n place, as they are familiar with conditions in practically all arts of the country and are in position to quote definite prices.



Bowstring Roof Truss

Bowstring Roof Trusses.—For industrial and many commercia structures, the bowstring truss is the most popular. This typ of truss has a curved top chord which starts from a poir approximately 10 inches high at the end of the truss, rising t a maximum height at center-line of about ⅛ of the total spa distance. This type of truss gives a curved roof shape. Becaus of its low height at the ends of truss, a minimum of masonr is required for parapet or fire walls.

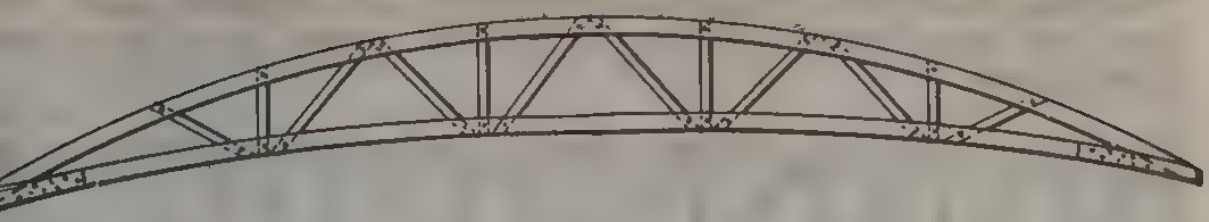
The truss may be left exposed, carrying roof load only, as i garages or industrial plants, or it can be designed to carry monc rail, floor systems, or other concentrated loads. The bowstrin truss is also designed to carry ceiling loads for use in stores, autc mobile agency salesrooms, and other commercial structures. Bow string trusses provide wind bracing for walls through diaphra action, and can be used with "knee braces" to develop portal actio in mill type buildings. Bowstring trusses are efficiently fabricate with bolts, thereby causing the least reduction in cross-sectiona area of the pieces connected.

Approximate Prices of Wood Bowstring Trusses

Designed with glued laminated or nailed 2"x3" or 2"x4" tc chords—built to conform to parabolic curve.

Erected in Chicago in lots of 5 or more, spaced 16'-0" c centers. 25 lb. live load. 40 lb. total load.

Span	Height	Price	Span	Height	Price
20'-0"	2'-6"	$190.00	90'-0"	11'-3"	$ 850.0
25'-0"	3'-1"	195.00	95'-0"	11'-10"	950.0
30'-0"	3'-9"	200.00	100'-0"	12'-6"	1030.0
35'-0"	4'-4"	205.00	105'-0"	13'-1"	1090.0
40'-0"	5'-0"	220.00	110'-0"	13'-9"	1140.0
45'-0"	5'-7"	240.00	115'-0"	14'-4"	1200.0
50'-0"	6'-3"	255.00	120'-0"	15'-0"	1260.0
55'-0"	6'-10"	310.00	125'-0"	15'-7"	1350.0
60'-0"	7'-6"	360.00	130'-0"	16'-3"	1440.0
65'-0"	8'-1"	420.00	135'-0"	16'-10"	1530.0
70'-0"	8'-9"	500.00	140'-0"	17'-6"	1620.0
75'-0"	9'-4"	570.00	145'-0"	18'-2"	1670.0
80'-0"	10'-0"	680.00	150'-0"	18'-9"	1760.0
85'-0"	10'-7"	770.00			



Crescent Design Roof Truss

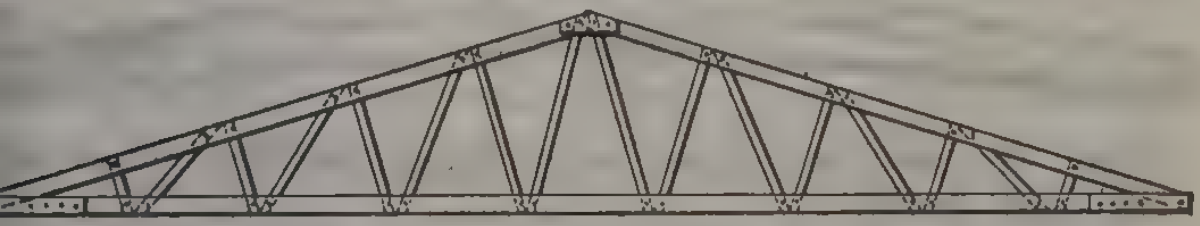
Crescent Type Roof Trusses.—The crescent type roof truss is becoming increasingly popular and is identified by its curved lower chord which affords a higher ceiling at the mid-span of the truss. The roof presents the curved roof, similar to the bowstring truss.

This truss presents a curved ceiling effect and is used in gymnasiums, auditoriums, low-cost churches, more elaborate stores and restaurants, etc. Recommended spans 20′-0″ to 85′-0″.

Approximate Prices of Crescent Type Wood Roof Trusses

Erected in Chicago in lots of 5 or more, spaced 16′-0″ on centers. 25 lb. live load. 40 lb. total load.

Span	Height	Camber	Price	Span	Height	Camber	Price
20′-0″	5′-0″	1′-0″	$240.00	55′-0″	8′-6″	2′-9″	$410.00
25′-0″	5′-6″	1′-3″	250.00	60′-0″	9′-0″	3′-0″	460.00
30′-0″	6′-0″	1′-6″	260.00	65′-0″	9′-6″	3′-3″	540.00
35′-0″	6′-6″	1′-9″	270.00	70′-0″	10′-0″	3′-6″	580.00
40′-0″	7′-0″	2′-0″	290.00	75′-0″	10′-6″	3′-9″	710.00
45′-0″	7′-6″	2′-3″	320.00	80′-0″	11′-0″	4′-0″	800.00
50′-0″	8′-0″	2′-6″	340.00	85′-0″	11′-6″	4′-3″	880.00

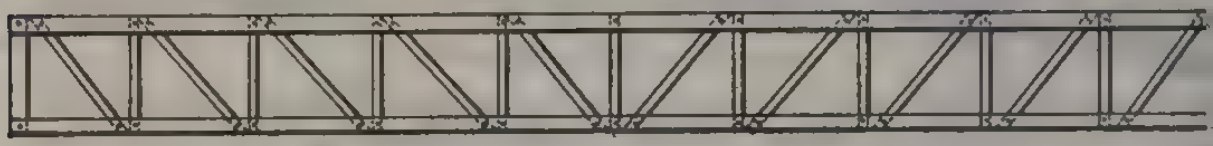


Belgian Design Roof Truss

Belgian Roof Trusses.—Belgian roof trusses are used where it is desirable to give a conventional building a more pleasing appearance through the use of a peaked roof. It is recognized by its sloping top chord and horizontal lower chord. In most instances, a ceiling is applied to the lower chord of these trusses, while the top chord may have shingles or slate as a covering. Used on some higher class store buildings and low-cost churches. Recommended for spans 20′-0″ to 85′-0″.

Belgian roof trusses are less efficient than the bowstring type

because the connections generally govern the member sizes and therefore cost approximately 50 percent more than bowstring type trusses.



Flat Top or Howe Design Roof Truss

Howe or Flattop Roof Trusses.—Industrial plants, warehouses, sheds, etc., when built of frame construction, often find use for a truss which absorbs wind loads in addition to carrying roof and concentrated loads. This truss is ideal for this purpose as it has parallel top and bottom chords and presents the over-all appearance of a large rectangle. Spans should not exceed 65 feet where costs are an important factor.

Howe roof trusses are generally more expensive than a bowstring type truss for reasons similar to those noted for the Belgian type trusses.

Glued Laminated Beam Construction.—Beams of glued laminated construction are popular where price is not the controlling factor.

They are made in uniform or tapered shapes. In the beam shape similar to illustration, they can be used in spans from 20′-0″ to 80′-0″.

They are used in schools, auditoriums, churches, stores and ranch-style homes.

They are made of kiln-dried structural woods bonded together by glue, applied under controlled conditions of temperature and pressure. They are planed and sanded to a very smooth surface and later treated with a transparent preservative, making their overall appearance very pleasing. With this type of construction the ceilings are usually omitted, leaving the beams exposed to the room below. Roof insulation is accomplished through the use of standard insulating boards placed upon the roof deck and covered with roofing material. Because of the purlin construction generally used, two or four inch decking is recommended.

Approximate Prices of Glued Laminated Wood Beams

Erected in quantities of 5 or more, spaced 16′-0″ on centers. 25 lb. live load, 40 lb. total load.

Span Feet	Center Height	End Height	Camber	Price
25′-0″	2′- 4″	0′- 9½″	0′-9″	$ 270.00
30′-0″	2′-10″	0′-11 ″	1′-0″	370.00
35′-0″	3′- 5″	1′- 1 ″	1′-3″	480.00
40′-0″	3′-11″	1′- 2½″	1′-6″	550.00
45′-0″	4′- 6″	1′- 4½″	1′-9″	700.00
50′-0″	5′- 1″	1′- 6½″	2′-0″	840.00
55′-0″	5′- 7″	1′- 8 ″	2′-3″	980.00
60′-0″	6′- 1″	1′- 9½″	2′-6″	1,050.00
65′-0″	6′- 8″	1′-11½″	2′-9″	1,340.00
70′-0″	7′- 3″	2′- 1½″	3′-0″	1,570.00
75′-0″	7′- 9″	2′- 3 ″	3′-3″	1,750.00
80′-0″	8′- 3″	2′- 4½″	3′-6″	1,970.00

Glued Laminated Three Hinged Arch

Another type of glued laminated construction is the three-hinged arch, which gains its support from floor level, incorporating column and beam in one compact design. Fabricated and finished in the manner of the glued beam, they are used where good appearance and function are the major factors and are used quite extensively in churches and schools.

Purlins are generally used to span the resulting bays and are covered with two inch decking and suitable insulating material.

This is the most expensive of the trusses discussed and costs from 5 to 6 times that of the bowstring type truss.

General Notes Regarding Trusses.—Where rafters are used between trusses, one-inch roof sheathing or ½ inch plywood is generally used. Where purlins are spaced 4′-0″ to 6′-0″ apart, two-inch sheathing is common practice. Purlins may be eliminated and wood decking of 4 to 6 inches may be used to span up to 18′-0″ between trusses.

The use of ceilings supported by the lower chord of the truss should be called to the attention of the truss designer, as it requires a heavier load.

Trusses may bear upon pilasters, steel columns, wood posts and plates, grillages or steel beams. A suitable steel bearing plate should be placed under each end of the truss to distribute the load throughout the masonry. Trusses may afford lateral support through angle irons fastened to truss and column.

Labor Framing Wood Roof Trusses.—When framing wood roof trusses, a carpenter experienced in truss construction will

Glued Laminated Beams in a Modern Church

handle and frame approximately the following amounts of lumber per hour on the various types of trusses:

Type of Truss	Ft. B.M per Hr.
Bowstring Type Trusses	40
Scissors and Gothic Type Trusses	30
Glued Laminated Type Trusses	15

Labor Erecting Wood Roof Trusses.—Erection of wood roof trusses in confined areas, or where the work is not heavy enough to support new loads, is usually accomplished with a gin pole. However, the bulk of wood truss erection is now accomplished by the use of special hydraulic cranes mounted on truck chassis and with lifting capacity up to 12 tons.

Buildings should be clear before the crane is brought in and all overhead electrical wires removed. Door opening should be of predetermined size to permit crane entrance.

Where a gin pole is used, the labor cost of erecting will vary with job conditions, as deep excavations, piles of brick, mortar boxes, lumber piles, etc., in the way of the derricks, will pre-

vent the erecting crew from making as good time as where a clear unobstructed space is available.

Under average working conditions on jobs requiring 5 or more trusses, a crew consisting of 5 men should erect one truss in the following time:

Length of Truss	No. Crew	Labor Hrs. per Truss	Hours	Labor Cost per Truss Rate	Total	Rate	Total
50′-0″	1	5	5	$.....	$.....	$6.75	$33.75
60′-0″	1	5	5	.....	.....	6.75	33.75
75′-0″	2	10	10	.....	.....	6.75	67.50
90′-0″	3	15	15	.....	.....	6.75	101.25
100′-0″	4	20	20	.....	.....	6.75	135.00
125′-0″	5	25	25	.....	.....	6.75	168.75

An erection crew usually consists of the foreman of the crew and 4 truss builders, as they are thoroughly experienced in this class of work.

TRUSSED RAFTERS

In recent years, designers and builders of multiple unit housing projects and typical plan residence developments have utilized truss principles in wood roof framing in an effort to reduce costs and to shorten construction time. Most small home constructors can benefit from their experience and research by considering this type of framing.

Trussed rafter framing is most effective on roofs of simple gable design without dormers, hips or valleys. Using trussed rafter framing, the following advantages may be realized:

1. Roof framing and ceiling framing are accomplished at the same time.
2. Members can be made of lighter stock, saving material and reducing weight.
3. Trusses may be pre-assembled.
4. Trusses can be erected rapidly and the job put under cover quickly.
5. Trusses permit the use of non-bearing partitions for all interior walls.

Types of Trussed Rafters.—Trussed rafters used in house building and similar construction, vary as to truss pattern and method of construction, depending upon design requirements and individual preference of the builder.

Several forms of truss patterns are as follows:

The W-type truss is the most popular type and is adaptable for spans from 18 ft. up to 40 ft.; roof slope from 2 in 12 to 6 in 12 and higher.

The kingpost truss is economical for spans 18 ft. up to 40 ft. with roof slopes from 2 in 12 to 6 in 12 and higher.

The scissors truss is used where sloping ceilings are desired for architectural effect. Economical spans are from 18 ft. to 36 ft.; roof slopes 5 in 12 to 6 in 12; ceiling slopes 2 in 12 to 3 in 12.

Trussed rafter construction varies principally as to the method of assembly, whether members are fastened together at joints by bolting or nailing, with split ring connectors and bolts, or flat, bent, pronged or toothed metal plates, or by gluing.

Using the bolting method, the members at all major joints, i.e., heel joints, apex, splices, etc., are connected by one or more bolts, or by using split rings to transfer the loads. In some cases, one or both ends of diagonal members may be fastened by nailing.

For nailed trussed rafters, all joint connections use metal truss plates, plywood gussets, and nails or ordinary nailed joints.

Fabrication of Trussed Rafter Members. — Fabrication of trussed rafter members is ideally suited for mass production methods, due to the large amount of repetition possible. In most cases, trussed rafters are symmetrical about their center lines so that corresponding members of each half are identical.

Since every member of a truss must do its share of the work, each one must be fabricated to exacting specifications. Design dimensions must be rigidly followed and all joints must have a good mechanical fit.

For efficient fabrication, a full-size layout should be made, either in the shop or on the subfloor of the building, after which one trussed rafter is carefully patterned and constructed with temporary connections. The unit may then be disassembled and the members used as templates for the balance of the trusses. On large projects, templates may be made of plywood or sheet metal.

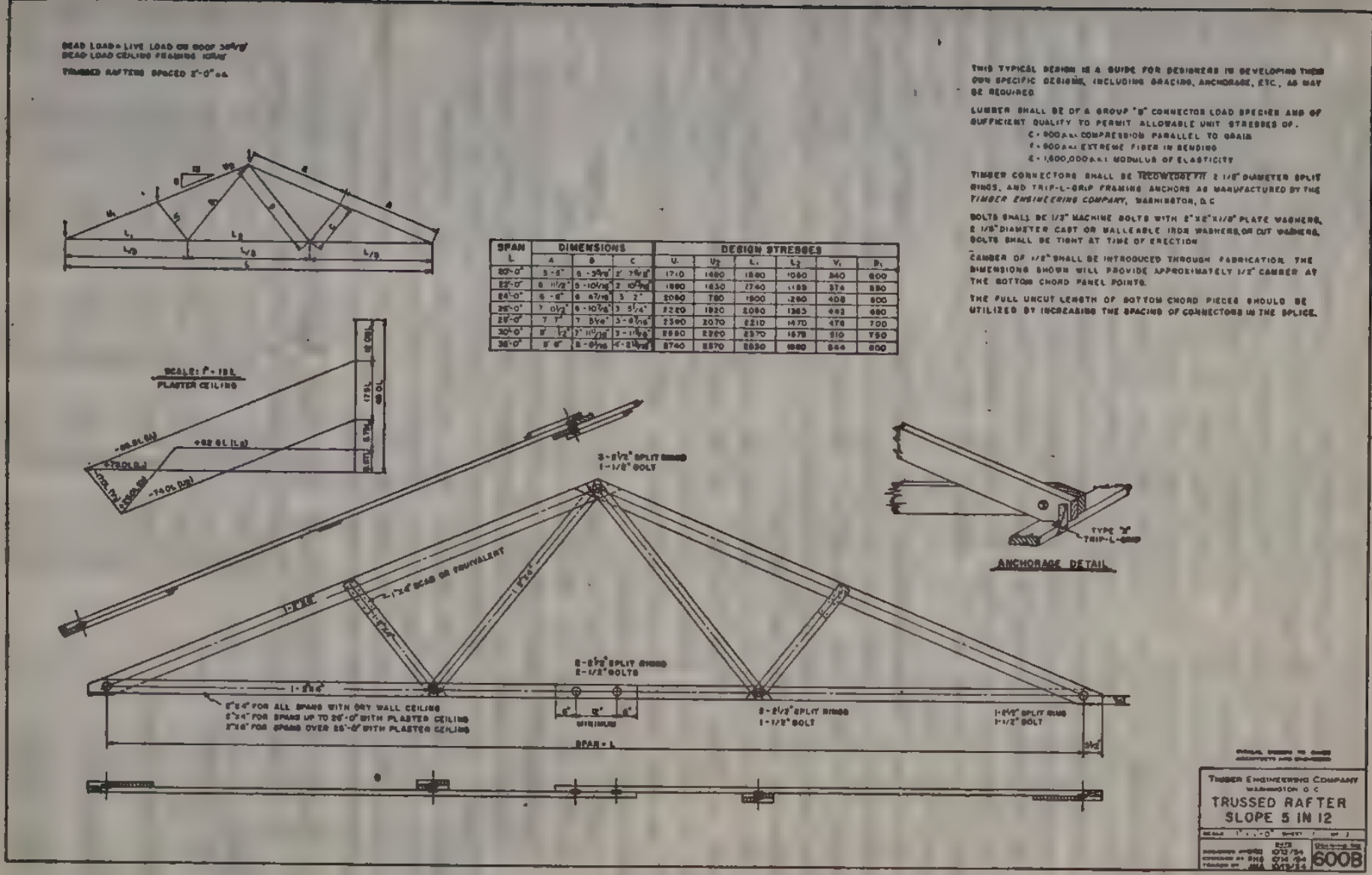
To insure smooth roof and ceiling lines after erection, layout measurements should be made to upper edges of top chords and lower edges of bottom chords to eliminate variations in stock lumber widths.

A word of caution—attention is called to the fact that the joints and fabrication of various sized trusses are similar so it is important to exercise caution and see that the appropriate drawings are consulted and followed when trusses are fabricated.

Split-Ring Connected Trussed Rafters

As previously mentioned, members are connected by means of bolts and split rings at all major joints as the split rings transfer the loads and the bolts hold the members in contact.

In order that each member may function properly, the bolt holes must be located exactly in accordance with design dimen-


DEAD LOAD + LIVE LOAD ON ROOF 30#/sq'
DEAD LOAD CEILING FRAMING 10#/sq'
TRUSSED RAFTERS SPACED 2'-0" o.c.
THIS TYPICAL DESIGN IS A GUIDE FOR DESIGNERS IN DEVELOPING THEIR OWN SPECIFIC DESIGNS, INCLUDING BRACING, ANCHORAGE, ETC., AS MAY BE REQUIRED.
LUMBER SHALL BE OF A GROUP "B" CONNECTOR LOAD SPECIES AND OF SUFFICIENT QUALITY TO PERMIT ALLOWABLE UNIT STRESSES OF:
C = 900 p.s.i. COMPRESSION PARALLEL TO GRAIN
f = 900 p.s.i. EXTREME FIBER IN BENDING
E = 1,600,000 p.s.i. MODULUS OF ELASTICITY
TIMBER CONNECTORS SHALL BE RECESSED FIT 2 1/8" DIAMETER SPLIT RINGS, AND TRIP-L-GRIP FRAMING ANCHORS AS MANUFACTURED BY THE TIMBER ENGINEERING COMPANY, WASHINGTON, D.C.
BOLTS SHALL BE 1/2" MACHINE BOLTS WITH 2" x 2" x 1/8" PLATE WASHERS, 2 1/8" DIAMETER CAST OR MALLEABLE IRON WASHERS, OR CUT WASHERS. BOLTS SHALL BE TIGHT AT TIME OF ERECTION.
CAMBER OF 1/8" SHALL BE INTRODUCED THROUGH FABRICATION. THE DIMENSIONS SHOWN WILL PROVIDE APPROXIMATELY 1/2" CAMBER AT THE BOTTOM CHORD PANEL POINTS.
THE FULL UNCUT LENGTH OF BOTTOM CHORD PIECES SHOULD BE UTILIZED BY INCREASING THE SPACING OF CONNECTORS IN THE SPLICE.
SCALE: 1" = 10'-0"
PLASTER CEILING
3-2 1/2" SPLIT RINGS
1-1/2" BOLT
2-1"x6" DEAD OR EQUIVALENT
1-2"x6"
2-2 1/2" SPLIT RINGS
2-1/2" BOLTS
1-2"x6"
2"x4" FOR ALL SPANS WITH DRY WALL CEILING
2"x4" FOR SPANS UP TO 26'-0" WITH PLASTER CEILING
2"x6" FOR SPANS OVER 26'-0" WITH PLASTER CEILING
MINIMUM
3-2 1/2" SPLIT RINGS
1-1/2" BOLT
1-2 1/2" SPLIT RING
1-1/2" BOLT
SPAN = L
TYPE "A" TRIP-L-GRIP
ANCHORAGE DETAIL
TIMBER ENGINEERING COMPANY
WASHINGTON D.C.
TRUSSED RAFTER
SLOPE 5 IN 12
600B

SPAN L	DIMENSIONS A	B	C	DESIGN STRESSES U	U_2	L_1	L_2	V_1	D_1
20'-0"	3'-8"	6'-3 9/16"	2'-7 9/16"	1710	1680	1580	1560	340	600
22'-0"	4'-1 1/2"	5'-10 1/16"	2'-10 5/16"	1890	1830	1740	1720	374	550
24'-0"	4'-6"	6'-4 7/16"	3'-2"	2060	1980	1900	1260	408	500
26'-0"	4'-10 1/2"	6'-10 7/8"	3'-5 1/4"	2220	1920	2050	1365	442	460
28'-0"	5'-3"	7'-3 5/16"	3'-8 5/16"	2390	2070	2210	1470	476	700
30'-0"	5'-7 1/2"	7'-10 3/4"	3'-11 5/8"	2560	2220	2370	1578	510	750
32'-0"	6'-0"	8'-0 7/16"	4'-2 3/4"	2740	2370	2530	1680	544	800

Design for Split-Ring Connected Trussed Rafter

sions and grooves for split rings must be of correct diameter, width and depth to provide a snug fit. Grooves must be cut with a grooving tool designed especially for this purpose.

Proper procedure for cutting grooves is as follows: after bolt locations have been established, drill bolt holes 1/16" larger in diameter than bolt; grooving tool is then fitted with a pilot mandrel of same diameter as drill and cutters are set to cut to a depth equal to half the width of the split ring; using bolt holes as pilot holes, concentric grooves are then cut in the faces of members which will contact each other. The grooving tool may also be fitted with the correct size drill bit, instead of a pilot mandrel, permitting both drilling and grooving operations to be done at one setup. For best results, drilling and grooving should be done with a bench drill or portable drill mounted in a drill stand.

Material Requirements for Split-Ring Connected Trussed Rafters.—The material requirements for split-ring connected trussed rafters are furnished through the courtesy of Timber Engineering Company, Washington, D.C., and are based on the following design conditions:

Trussed rafters are designed to support a dead load plus live load on roof of 35 lbs. per sq. ft. and a ceiling load of 10 lbs. per sq. ft. with rafters spaced at 2'-0" centers.

Lumber shall be good grade of sufficient quality to permit the following unit stresses:

c=900 lbs. per sq. in. Compression parallel to grain.

f=900 lbs. per sq. in. Extreme fiber in bending.

E=1,600,000 lbs. per sq. in. Modulus of elasticity.

All split rings to be 2½" diameter. All bolts to be ½" diameter machine bolts. Washers may be 2"x2"x⅛" plate washers, 2⅛" diameter cast or malleable iron washers or cut washers.

No allowances have been included for roof overhangs.

Quantities listed for diagonals are most economical lengths to produce a long and short member from a single length.

Material Requirements for One Split-Ring Connected Trussed Rafter of Various Spans for a 4 in 12 Roof Slope

Span	20'-0"	24'-0"	26'-0"	28'-0"	30'-0"	32'-0"
Top Chords	2-2x6	2-2x6	2-2x6	2-2x8	2-2x8	2-2x8
	12'-0"	14'-0"	16'-0"	16'-0"	18'-0"	18'-0"
Bottom Chords	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	12'-0"	14'-0"	16'-0"	16'-0"	18'-0"	18'-0"
Diagonals	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	8'-0"	10'-0"	10'-0"	12'-0"	12'-0"	12'-0"
Joint Scabs	1-1x4	1-1x4	1-1x4	1-1x4	1-1x4	1-1x4
	2'-0"	2'-0"	2'-0"	3'-0"	3'-0"	3'-0"

Material Requirements for One Split-Ring Connected Trussed Rafter of Various Spans for a 4 in 12 Roof Slope

Total Ft. B.M.	51⅓	60⅔	67⅓	81	89	89
Split Rings	11	11	11	13	13	13
Bolts, ½"x4"	4	4	4	6	6	6
½"x6"	2	2	2	2	2	2
½"x7½"	1	1	1	1	1	1
Washers	14	14	14	18	18	18
Nails, 8d	16	16	16	16	16	16

Material Requirements for One Split-Ring Connected Trussed Rafter of Various Spans for a 5 in 12 Roof Slope

Span	20'-0"	24'-0"	26'-0"	28'-0"	30'-0"	32'-0"
Top Chords	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6
	12'-0"	14'-0"	16'-0"	18'-0"	18'-0"	20'-0"
Bottom Chords	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	12'-0"	14'-0"	16'-0"	16'-0"	18'-0"	18'-0"
Diagonals	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	10'-0"	12'-0"	12'-0"	12'-0"	14'-0"	14'-0"
Joint Scabs	1-1x4	1-1x4	1-1x4	1-1x4	1-1x4	1-1x4
	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"
Total Ft. B.M.	54	63⅓	70	74	79⅓	83⅓
Split Rings	11	11	11	11	11	11
Bolts, ½"x4"	4	4	4	4	4	4
½"x6"	2	2	2	2	2	2
½"x7½"	1	1	1	1	1	1
Washers	14	14	14	14	14	14
Nails, 8d	16	16	16	16	16	16

Material Requirements for One Split-Ring Connected Trussed Rafter of Various Spans for a 6 in 12 Roof Slope

Span	20'-0"	24'-0"	26'-0"	28'-0"	30'-0"	32'-0"
Top Chords	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6
	14'-0"	16'-0"	16'-0"	18'-0"	18'-0"	20'-0"
Bottom Chords	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	12'-0"	14'-0"	16'-0"	16'-0"	18'-0"	18'-0"
Diagonals	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	10'-0"	12'-0"	14'-0"	14'-0"	16'-0"	16'-0"
Joint Scabs	1-1x4	1-1x4	1-1x4	1-1x4	1-1x4	1-1x4
	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"
Total Ft. B.M.	58	67⅓	72⅔	76⅔	82	86
Split Rings	11	11	11	11	11	11
Bolts, ½" x 4"	4	4	4	4	4	4
½" x 6"	2	2	2	2	2	2
½" x 7½"	1	1	1	1	1	1
Washers	14	14	14	14	14	14
Nails, 8d	16	16	16	16	16	16

Material Requirements for One Split-Ring Connected Trussed Rafter of Various Spans for a 7 in 12 Roof Slope

Span	20'-0"	24'-0"	26'-0"	28'-0"	30'-0"	32'-0"
Top Chords	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6
	14'-0"	16'-0"	16'-0"	18'-0"	20'-0"	20'-0"
Bottom Chords	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	12'-0"	14'-0"	16'-0"	16'-0"	18'-0"	18'-0"
Diagonals	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	12'-0"	14'-0"	14'-0"	16'-0"	16'-0"	18'-0"
Joint Scabs	1-1x4	1-1x4	1-1x4	1-1x4	1-1x4	1-1x4
	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"
Total Ft. B.M.	60⅔	70	72⅔	79⅓	86	88⅔
Split Rings	11	11	11	11	11	11
Bolts, ½" x 4"	4	4	4	4	4	4
½" x 6"	2	2	2	2	2	2
½" x 7½"	1	1	1	1	1	1
Washers	14	14	14	14	14	14
Nails, 8d	16	16	16	16	16	16

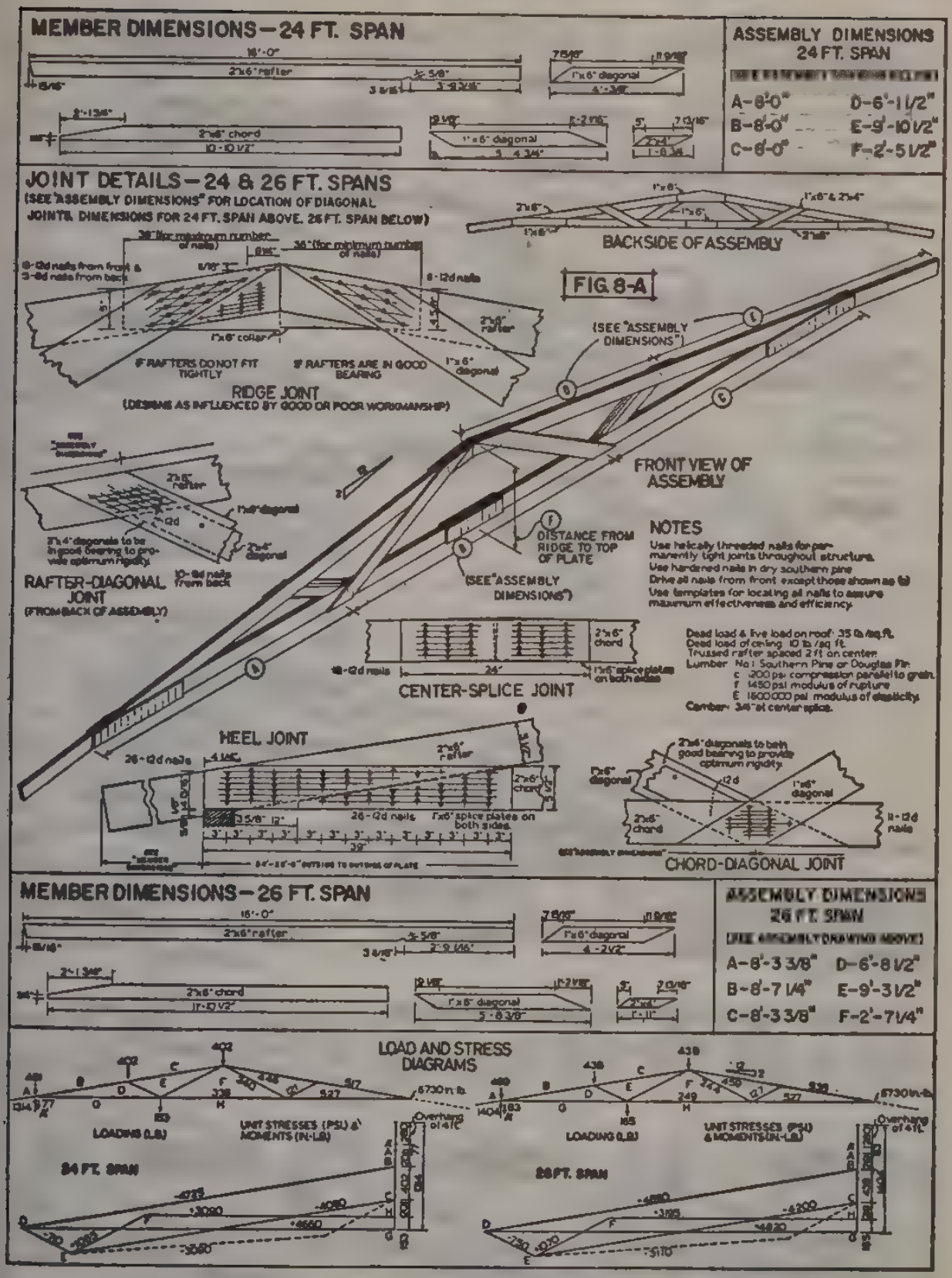
Nailed Trussed Rafters

Many contractors prefer nailed trussed rafters for the simplicity of their construction. For small one-house jobs, containing only 20 to 30 rafter units, they may be easily fabricated and assembled on the job, using simple hand tools—hand saw and hammer. They are also adaptable to mass production methods using portable power tools or shop equipment, for projects involving thousands of trussed rafters.

Another advantage of these all-nailed trussed rafters is the fact that only standard dimension lumber and nails are used in the case of "W" and scissor-type rafters, and standard plywood for gusset and splice plates. In the case of kingpost trussed rafters, no steel plates, bolts, special fasteners, glue, etc. are required.

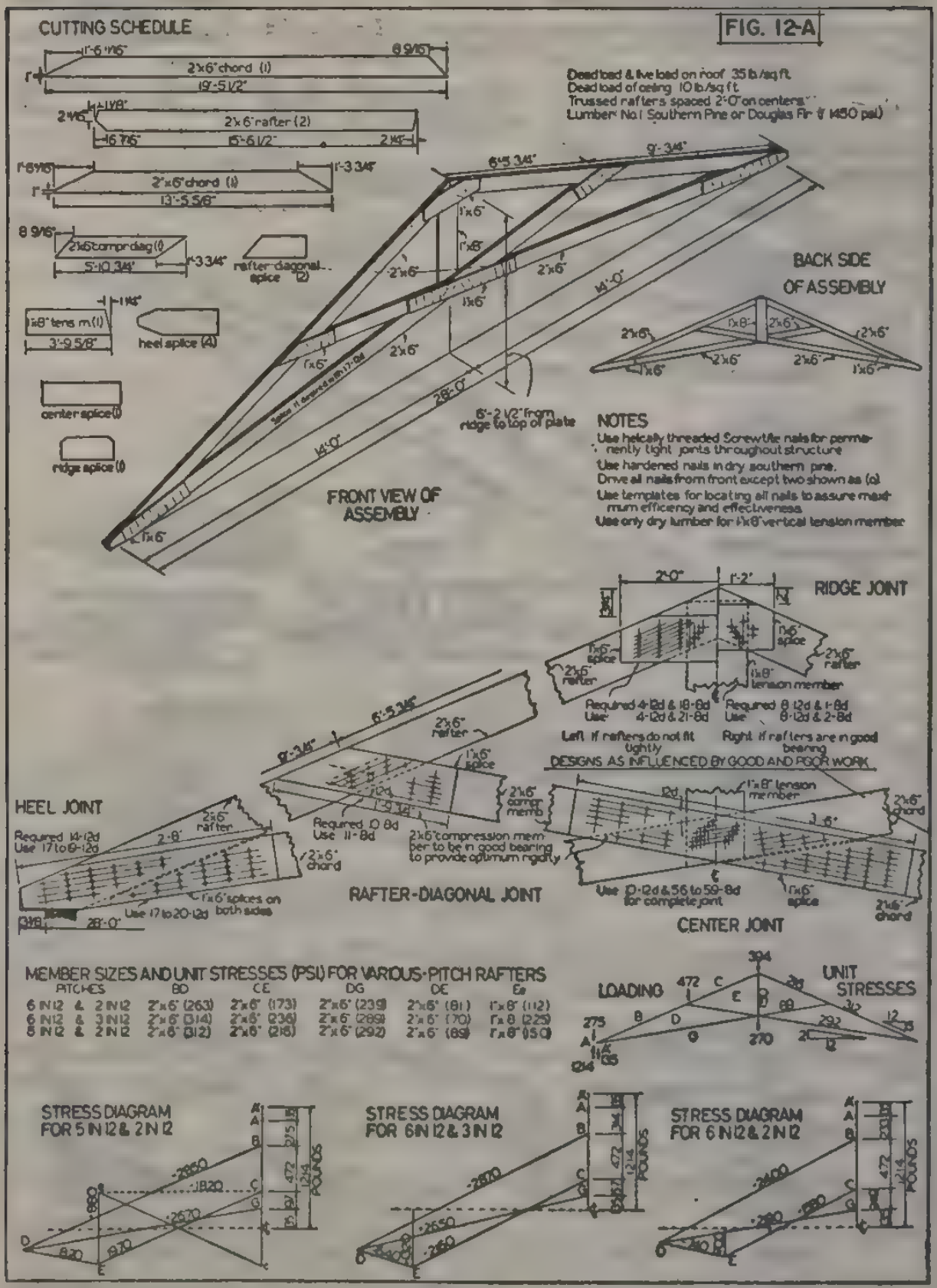
To function properly, nailed trussed rafters must be fabricated and assembled with the same degree of accuracy as bolted and other types of trussed rafters. Fabrication and assembly of rafter units must adhere closely to design dimensions and joint details. It is important to have good bearing fits for top chord and compression diagonal member joints. Location, number and size of nails must be in accordance with joint details.

For fast, accurate marking of nail locations, use nailing templates and spray colored paint or shellac through template openings with a paint gun or an aerosol-type container. To permit nailing from one side without nail clinching, use helically threaded nails. For dry, dense lumber, use hardened nails, which are more slender and less likely to split material.


MEMBER DIMENSIONS—24 FT. SPAN
ASSEMBLY DIMENSIONS 24 FT. SPAN
A-8'0" D-6'-1 1/2"
B-8'-0" E-9'-10 1/2"
C-8'-0" F-2'-5 1/2"
JOINT DETAILS—24 & 26 FT. SPANS
(SEE "ASSEMBLY DIMENSIONS" FOR LOCATION OF DIAGONAL JOINTS. DIMENSIONS FOR 24 FT. SPAN ABOVE. 26 FT. SPAN BELOW)
BACKSIDE OF ASSEMBLY
FIG. 8-A
RIDGE JOINT
(DESIGNS AS INFLUENCED BY GOOD OR POOR WORKMANSHIP)
IF RAFTERS DO NOT FIT TIGHTLY
IF RAFTERS ARE IN GOOD BEARING
FRONT VIEW OF ASSEMBLY
(SEE "ASSEMBLY DIMENSIONS")
DISTANCE FROM RIDGE TO TOP OF PLATE
RAFTER-DIAGONAL JOINT
(FROM BACK OF ASSEMBLY)
NOTES
Use helically threaded nails for permanently tight joints throughout structure.
Use hardened nails in dry southern pine
Drive all nails from front except those shown as (a)
Use templates for locating all nails to assure maximum effectiveness and efficiency
Dead load & live load on roof 25 lb./sq.ft.
Dead load of ceiling 10 lb./sq.ft.
Trussed rafter spaced 2 ft on center
Lumber No.1 Southern Pine or Douglas Fir
c 1200 psi compression parallel to grain
f 1450 psi modulus of rupture
E 1600000 psi modulus of elasticity
Camber 3/4" at center splice.
CENTER-SPLICE JOINT
HEEL JOINT
CHORD-DIAGONAL JOINT
MEMBER DIMENSIONS—26 FT. SPAN
ASSEMBLY DIMENSIONS 26 FT. SPAN
A-8'-3 3/8" D-6'-8 1/2"
B-8'-7 1/4" E-9'-3 1/2"
C-8'-3 3/8" F-2'-7 1/4"
LOAD AND STRESS DIAGRAMS
LOADING (LB)
UNIT STRESSES (PSI) & MOMENTS (IN-LB)
24 FT. SPAN
26 FT. SPAN

Design and Details for a Low Rise Nailed Trussed Rafter

While the use of seasoned lumber is not absolutely essential in the construction of nailed truss rafters, better results are obtained with dry lumber and its use is recommended. This is


CUTTING SCHEDULE
FIG. 12-A
2x6" chord (1)
19'-5 1/2"
2x6" rafter (2)
16 7/16"
15'-6 1/2"
2 1/16"
2x6" chord (1)
13'-5 5/8"
2x6 comp diag (1)
5'-10 3/4"
rafter-diagonal splice (2)
1x8" tension (1)
3'-9 5/8"
heel splice (4)
center splice (1)
ridge splice (1)
Dead load & live load on roof 35 lb/sq ft
Dead load of ceiling 10 lb/sq ft
Trussed rafters spaced 2'-0" on centers
Lumber No 1 Southern Pine or Douglas Fir @ 1450 psi
FRONT VIEW OF ASSEMBLY
BACK SIDE OF ASSEMBLY
6'-2 1/2" from ridge to top of plate
28'-0"
14'-0"
NOTES
Use helically threaded Screwtite nails for permanently tight joints throughout structure
Use hardened nails in dry southern pine.
Drive all nails from front except two shown as (a)
Use templates for locating all nails to assure maximum efficiency and effectiveness
Use only dry lumber for 1"x8" vertical tension member
RIDGE JOINT
Required 4-12d & 18-8d Use 4-12d & 21-8d
Required 8-12d & 1-8d Use 8-12d & 2-8d
Left if rafters do not fit tightly
Right if rafters are in good bearing
DESIGNS AS INFLUENCED BY GOOD AND POOR WORK
HEEL JOINT
Required 14-12d Use 17 to 19-12d
Use 17 to 20-12d both sides
RAFTER-DIAGONAL JOINT
Required 10 8d Use 11-8d
2x6" compression member to be in good bearing to provide optimum rigidity
CENTER JOINT
Use 10-12d & 56 to 59-8d for complete joint

MEMBER SIZES AND UNIT STRESSES (PSI) FOR VARIOUS-PITCH RAFTERS

PITCHES	BD	CE	DG	DE	Ea
6 IN 12 & 2 IN 12	2"x6" (263)	2"x6" (173)	2"x6" (239)	2"x6" (81)	1"x8" (112)
6 IN 12 & 3 IN 12	2"x6" (314)	2"x6" (236)	2"x6" (289)	2"x6" (70)	1"x8 (225)
5 IN 12 & 2 IN 12	2"x6" (312)	2"x6" (218)	2"x6" (292)	2"x6" (69)	1"x8" (150)

Design and Details for a Scissors Type Nailed Trussed Rafter

particularly true for splice plates over 4″ wide and is a design requirement for 8″ wide material. 1″ x 8″ splice plates made from green lumber tend to split along nail rows, when undergoing shrinkage, causing the joint to fail.

Material Requirements for Nailed Trussed Rafters.—The material requirements for nailed trussed rafters are furnished through the courtesy of Dr. E. George Stern, Research Professor of Wood Construction at the Virginia Polytechnic Institute, Blacksburg, Va. Truss designs for the various spans and roof slopes are based on experimental data obtained in the Wood Research Laboratory of the Virginia Engineering Experimental Station under the direction of Dr. Stern. Trussed rafters, constructed in accordance with these designs, have been subjected to all types of tests and have proved conclusively to be of ample strength for the use intended.

Material requirements for trussed rafters are based on the following design conditions:

Trussed rafters are designed to support a dead load plus live load on roof of 35 lbs. per sq. ft. and a ceiling load of 10 lbs. per sq. ft. with rafters spaced at 2′-0″ centers.

Lumber shall be stress-graded No. 1 southern pine or Douglas fir, preferably seasoned 12 to 15 percent moisture content, permitting the following unit stresses:

c=1350 lbs. per sq. in. Compression parallel to grain.

f=1500 lbs. per sq. in. Extreme fiber stress.

E=1,760,000 lbs. per sq. in. Modulus of elasticity.

Quantities listed for diagonals are most economical lengths to produce a long and short member from a single length.

Material Requirements for One Nailed Trussed Rafter of Various Spans for a 2 in 12 Roof Slope

Span	18′-0″	20′-0″	24′-0″	26′-0″	28′-0″	30′-0″
Approx. Overhang	3′-0″	2′-0″	4′-0″	3′-0″	4′-0″	3′-0″
Top Chords	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6
	12′-0″	12′-0″	16′-0″	16′-0″	18′-0″	18′-0″
Bottom Chords	2-2x4	2-2x4	2-2x6	2-2x6	2-2x6	2-2x6
	8′-0″	10′-0″	12′-0″	12′-0″	14′-0″	14′-0″
Diagonals	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6
	8′-0″	10′-0″	10′-0″	10′-0″	12′-0″	12′-0″
	1-2x4	1-2x4	1-2x4	1-2x4	1-2x4	1-2x4
	4′-0″	4′-0″	4′-0″	4′-0″	6′-0″	6′-0″

Material Requirements for One Nailed Trussed Rafter of Various Spans for a 2 in 12 Roof Slope—Continued

Splice Plates	4-1x4	4-1x4	4-1x6	4-1x6	4-1x6	4-1x6
	3'-0"	3'-0"	3'-6"	3'-6"	3-6"	3'-6"
	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6
	3'-0"	3'-0"	2'-0"	2'-0"	3'-0"	3'-0"
	1-1x8	1-1x8	1-1x8	1-1x8	1-1x8	1-1x8
	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"
Total Ft. B.M.	55	59⅔	80⅓	80⅓	92⅔	92⅔
Nails, 12d	144	144	198	198	242	242
8d	40	40	58	58	72	72

Material Requirements for One Nailed Trussed Rafter of Various Spans for a 3 in 12 Roof Slope

Span	24'-0"	26'-0"	28'-0"	30'-0"	32'-0"	34'-0"
Approx. Overhang	3'-6"	4'-0"	3'-6"	4'-0"	3'-6"	2'-6"
Top Chords	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6	2-2x6
	16'-0"	18'-0"	18'-0"	20'-0"	20'-0"	20'-0"
Bottom Chords	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	12'-0"	14'-0"	14'-0"	16'-0"	16'-0"	18'-0"
Diagonals	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6
	10'-0"	10'-0"	12'-0"	12'-0"	12'-0"	14'-0"
	1-2x4	1-2x4	1-2x4	1-2x4	1-2x4	1-2x4
	6'-0"	6'-0"	6'-0"	6'-0"	8'-0"	8'-0"
Splice Plates	4-1x4	4-1x4	4-1x4	4-1x4	4-1x4	4-1x4
	3'-0"	3'-0"	4'-0"	4'-0"	4'-0"	4'-0"
	3-1x6	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6
	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"
	....	1-1x6	1-1x6	1-1x6	1-1x8	1-1x8
	....	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"
Total Ft. B.M.	70½	77⅔	81	87⅔	89⅔	94⅓
Nails, 12d	138	138	146	146	168	168
8d	38	46	58	60	56	56

Material Requirements for One Nailed Trussed Rafter of Various Spans for a 5 in 12 Roof Slope

Span	24'-0"	26'-0"	28'-0"	30'-0"	32'-0"	34'-0"
Approx. Overhang	3¼"	3¼"	3¼"	3¼"	3¼"	3¼"
Top Chords	2-2x4	2-2x4	2-2x6	2-2x6	2-2x6	2-2x6
	14'-0"	16'-0"	16'-0"	18'-0"	18'-0"	20'-0"
Bottom Chords	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4	2-2x4
	12'-0"	14'-0"	14'-0"	16'-0"	16'-0"	18'-0"
Diagonals	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6	2-1x6
	12'-0"	12'-0"	14'-0"	14'-0"	14'-0"	16'-0"
	1-2x4	1-2x4	1-2x4	1-2x4	1-2x4	1-2x4
	6'-0"	8'-0"	8'-0"	8'-0"	8'-0"	10'-0"

Material Requirements for One Nailed Trussed Rafter of Various Spans for a 5 in 12 Roof Slope—Continued

Splice Plates	6-1x6	6-1x6	4-1x4	4-1x4	4-1x4	4-1x4
	2'-0"	2'-0"	3'-0"	3'-0"	3'-0"	3'-0"
	1-1x6	1-1x6	2-1x6	2-1x6	2-1x6	2-1x6
	3'-0"	3'-0"	2'-0"	2'-0"	2'-0"	2'-0"
	....	....	1-1x6	1-1x6	1-1x8	1-1x8
	....	....	3'-0"	3'-0"	3'-0"	3'-0"
Total Ft. B.M.	57 5/6	64 5/6	77 1/2	84 1/6	84 2/3	94 2/3
Nails, 12d	100	112	110	110	124	124
8d	26	18	42	44	34	34

Material Requirements for One Scissors Type Nailed Trussed Rafter of Various Spans for a 5 in 12 Roof Slope and 2 in 12 Ceiling Slope

Span	18'-0"	20'-0"	24'-0"	26'-0"	28'-0"	30'-0"
Overhang	2"	2"	3 3/8"	3 3/8"	3 3/8"	3 3/8"
Top Chords	2-2x4	2-2x4	2-2x4	2-2x6	2-2x6	2-2x6
	10'-0"	12'-0"	14'-0"	16'-0"	16'-0"	18'-0"
Bottom Chords	2-2x4	2-2x4	2-2x4	2-2x4	2-2x6	2-2x6
& Compr. Diag.	12'-0"	14'-0"	18'-0"	18'-0"	20'-0"	22'-0"
Vert. Member	1-1x8	1-1x8	1-1x8	1-1x8	1-1x8	1-1x8
	3'-0"	3'-0"	4'-0"	4'-0"	4'-0"	5'-0"
Splice Plates	4-1x4	4-1x4	4-1x4	4-1x4	4-1x6	4-1x6
	2'-6"	2'-6"	3'-0"	3'-0"	3'-0"	3'-0"
	2-1x4	2-1x4	2-1x4	2-1x4	3-1x6	3-1x6
	1'-6"	1'-6"	1'-6"	1'-6"	2'-0"	2'-0"
	1-1x6	1-1x6	1-1x6	1-1x6	1-1x6	1-1x6
	2'-0"	2'-0"	2'-0"	2'-0"	4'-0"	4'-0"
	1-1x6	1-1x6	1-1x6	1-1x6	.....	.....
	3'-0"	3'-0"	4'-0"	4'-0"	.....	.....
Total Ft. B.M.	38 1/6	43 1/2	53 1/3	66 2/3	85 2/3	94 1/3
Nails, 12d	63	63	78	80	104	109
8d	106	106	115	120	147	147

All-Nailed Kingpost Trussed Rafters.—All nailed kingpost trussed rafters are a result of research conducted at Virginia Polytechnic Institute under the sponsorship of Independent Nail & Packing Company of Bridgewater, Mass. The studies, which have been supported by this largest manufacturer of improved fasteners, have brought about a new era in nail technology and wood construction. Indebtedness to Independent Nail for their continuing cooperation and foresight is acknowledged.

Test data are available on request from the V.P.I. Wood Research Laboratory at Blacksburg, Va. Samples of the hardened-

Material Requirements for All-Nailed Kingpost Trussed Rafters with ½" Plywood Gusset and Splice Plates

Span	20'-8"	24'-8"	28'-8"	32'-8"	36'-5½"	40'-0"
Roof Slope	3/12	2/12	3/12	2/12	5/12	4/12
Overhang	19"	18"	16"	18"	5½"	12"
Top Chord, 2 ea.	2x4x12'	2x4x14'	2x6x16'	2x6x18'	2x8x20'	2x8x22'
Bottom Chord, 2 ea.	2x4x10'	2x4x12'	2x4x14'	2x6x16'	2x6x18'	2x6x20'
Post, 1 (or 2) ea.	2x4x2'	2x4x2'-3⅝"	2x4x3'-10½"	2x4x3'-1⅞"	2x6x8'	2-2x4x6'
Heel Gusset, 4 ea.	2'-9"x1'¾"	4'x1'-3¼"	3'x1'-6¼"	4'x1'-7"	4'x2'-7"	4'x2'-3½"
Ridge Gusset, 2 ea.	2'-9"x7"	4'x7⅝"	3'x10⅛"	5'x1'-0"	4'x1'-4"	4'x1'-5¼"
Center Splice, 2 ea.	3'x4"	4'x4"	4'x4"	4'x6"	4'x5¾"	4'x9"
Lumber, Bd. ft.	31⅓	36	55	71	100	109
Plywood, Sq. Ft. (2½"x0.135")	16	24	22	36	43	44
Hardened steel Nos.	140	168	218	304	308	342
Spiral-Thread, Hi-Load Nails, lb.	1.39	1.66	2.16	3.01	3.05	3.40

steel spiral-thread Hi-Load nails, used for the assembly of the trussed rafters, can be obtained from the manufacturer, the Independent Nail & Packing Company of Bridgewater, Mass.

Labor Required to Fabricate and Assemble Trussed Rafters.—The labor required to fabricate and assemble trussed rafters will vary with the scope of the job, number of rafter units and production methods used, also upon the size of the rafter units.

On an average one-house job, two carpenters will require about 6 hours to make a layout on the subfloor, place jig stops to guide assembly work and construct a pilot truss with temporary connections, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Carpenter	12	$.....	$.....	$6.75	$81.00

For the balance of the rafter units, a 2-man crew, using portable power equipment for cutting, drilling, etc., should fabricate, assemble and stockpile 10 to 12 24 ft. to 28 ft. span trussed rafters per 8-hr. day, at the following labor cost per truss:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$.....	$.....	$6.75	$10.13

For larger spans, up to 36 ft., add about 5 percent to above costs. For smaller spans, reduce costs about 5 percent.

On large projects, containing several thousand trussed rafters, where the expense of setting up a shop for fabrication and assembly is warranted, a 2-man crew should complete 20 to 24 trussed rafters per 8-hr. day, at the following labor cost per truss:

	Hours	Rate	Total	Rate	Total
Carpenter	.75	$.....	$.....	$6.75	$5.07

To the above, add equipment charges and cost of setting up and dismantling fabrication shop.

The above costs may be applied to either bolted trussed rafters or nailed trussed rafters as any differential in their costs will vary with the individual builders.

Labor Erecting Trussed Rafters.—Erection of trussed rafters, for one-story structures, can usually be accomplished with a 4-man crew — 2 laborers carrying rafter units from stockpile to setting location, placing units in an inverted position on the bearing wall plates and tilting up into an erect position ready for 2 carpenters to anchor and brace same in final position. For efficient operation, the layout of rafter locations should be marked on the wall plates and metal framing anchors set in place before erection is started. The 4-man crew should lay out,

set anchors and erect into place 22 to 26 trussed rafters, up to 28'-0" span, per 8-hr. day, at the following labor cost per truss:

	Hours	Rate	Total	Rate	Total
Carpenter	0.67	$.....	$.....	$6.75	$4.52
Labor	0.67		.....	5.00	3.35
Cost per truss	1.34		$.....		$7.87

For spans greater than 28'-0" it may be necessary to add an extra man to the crew.

WOOD FLOORS

Estimating Quantities of Wood Flooring.—When estimating the quantity of wood flooring required for any job, take the actual number of sq. ft. in any room or space to be floored, and add allowances as given in the following tables:

Measured Size Inches	Finished Size Inches	No. of Pieces in Bundle	Add for Waste Percent	To Obtain Quantity of Flooring Required Multiply Area by	No. Ft. Flg. Required for 100 Sq. Ft. Floor
1x1	$\frac{3}{8}$x$\frac{7}{8}$	24	16$\frac{2}{3}$	1$\frac{1}{6}$ or 1.17	117
1x2	$\frac{3}{8}$x1$\frac{1}{2}$	24	33$\frac{1}{3}$	1$\frac{1}{3}$ or 1.33	133
1x2$\frac{1}{2}$	$\frac{3}{8}$x2	24	25	1$\frac{1}{4}$ or 1.25	125
1x2$\frac{1}{4}$	$\frac{25}{32}$x1$\frac{1}{2}$	12	50$\frac{1}{3}$	1$\frac{1}{2}$ or 1.50	150
1x2$\frac{3}{4}$	$\frac{25}{32}$x2	12	37$\frac{1}{2}$	1$\frac{3}{8}$ or 1.375	137$\frac{1}{2}$
1x3	$\frac{25}{32}$x2$\frac{1}{4}$	12	33$\frac{1}{3}$	1$\frac{1}{3}$ or 1.33	133
1x4	$\frac{25}{32}$x3$\frac{1}{4}$	8	25	1$\frac{1}{4}$ or 1.25	125

Amount of Surface 1,000 Feet of Flooring Will Cover and Quantity of Nails Required To Lay It

Size Flooring	How Measured	Will Cover Sq. Ft. Fl.	Nailed Every	Lbs. Nails Req'd. Cut nails	Lbs. Nails Req'd. Helically threaded nails
$\frac{3}{8}$x1$\frac{1}{2}$	1x2	750	8 in.	20 lbs.	
$\frac{3}{8}$x2	1x2$\frac{1}{2}$	800	8 in.	17	
$\frac{25}{32}$x1$\frac{1}{2}$	1x2$\frac{1}{4}$	667	12 in.	70	60 lbs.
$\frac{25}{32}$x2	1x2$\frac{3}{4}$	727	12 in.	56	47
$\frac{25}{32}$x2$\frac{1}{4}$	1x3	750	10 in.	64	54
$\frac{25}{32}$x3$\frac{1}{4}$	1x4	800	10 in.	29	24

Drill flooring for nails, if possible, for best results. No predrilling is required for helically threaded nails.

Note: The above figures are based on laying the flooring straight across a rectangular room without producing any design whatever.

Rules for Grading Hardwood Flooring.—In many instances the specifications of the architects and owners are confusing

and not in accordance with the standard rules for grading as adopted by the manufacturers. The rules adopted by the flooring manufacturers are given below, so that they may be compared with the architect's specifications, and the proper grade of flooring figured.

FIRST GRADE

First Grade—$\frac{25}{32}$ inch and thicker, shall have the face practically free of all defects, but the varying natural color of the wood shall not be considered a defect. Standard lengths in all widths in this grade shall be in 2 foot bundles and longer as the stock will produce. Not over 30% of the total footage shall be in bundles under 4 feet, and not more than 17% of the total footage shall be in 2-foot bundles.

SECOND GRADE

Second Grade—$\frac{25}{32}$ inch and thicker, will admit tight, sound knots and slight imperfections in dressing, but must lay without waste. Standard lengths in all widths in this grade shall be in 2 foot bundles and longer as the stock will produce. Not over 45% of the total footage shall be in bundles under 4 feet, and not more than 25% of the total footage shall be in 2-foot bundles.

THIRD GRADE

Third Grade—$\frac{25}{32}$ inch and thicker must be of such character as will lay and give a good serviceable floor. Standard lengths in all widths of this grade shall be in $1\frac{1}{4}$ foot bundles and longer as the stock will produce. Not over 65% of the total footage shall be in bundles under 4 feet, and not more than 27% of the total footage shall be in $1\frac{1}{4}$-foot bundles.

COMBINATION GRADES

Second and Better Grade—In all thicknesses and widths is a combination of First and Second Grades developing in the strip without crosscutting for each grade. The lowest grade pieces admissible shall not be less than standard Second Grade. Standard lengths in all widths in this grade shall be in 2 foot bundles and longer as the stock will produce. Not over 40% of the total footage shall be in bundles under 4 feet, and not more than 20% shall be in 2-foot bundles.

Third and Better Grade—In all thicknesses and widths is a combination of First, Second and Third Grades developing in a strip without crosscutting. The lowest grade pieces admissible shall not be less than standard Third Grade. Standard lengths in all widths of this grade shall be in $1\frac{1}{4}$ foot bundles and longer as the stock will produce. Not over 50% of the total footage shall be in bundles under 4 feet.

SPECIAL COLOR GRADES

The Finest Grades Produced

SELECTED FIRST GRADE LIGHT NORTHERN HARD MAPLE. This grade is selected for light color. The color tones in individual strips will vary somewhat, but after laying, this grade provides a luxurious "light" appearing floor.

SELECTED FIRST GRADE AMBER NORTHERN HARD MAPLE. This grade is selected for amber color. The color tones in individual strips will vary somewhat, but after laying, this grade provides a luxurious "amber" appearing floor.

TO ASCERTAIN QUANTITY OF FLOORING REQUIRED

Face Widths	Thickness ½", ⅝" and 25/32"	Thickness ⅜"
Tongue and Groove Flooring		
1½" Face	53⅓%	36⅔%
2" Face	40½%	28%
2¼" Face	36⅔%	25½%
3¼" Face	27%	not made
Jointed Flooring		
2¼" Face	36⅔%	not made
2½" Face	23%	not made
3¼" Face	27%	not made
3⅜" Face	25⅔%	not made
3½" Face	24⅞%	not made

OAK FLOORING

Quarter Sawed

CLEAR.—The face shall be practically clear, admitting an average of ⅛ of an inch of bright sap. The question of color shall not be considered. Bundles to be 2 foot and up. Average length 4¼ feet.

SELECT.—The face may contain sap, small streaks, pin worm holes, burls, slight imperfections in working, and small tight knots which do not average more than one to every 3 feet. Bundles to be 2 foot and up. Average length 3¾ feet.

Plain Sawed

CLEAR.—The face shall be practically clear, admitting an average of ⅛ of an inch of bright sap. The question of color shall not be considered. Bundles to be 2 foot and up. Average length 4¼ feet.

SELECT.—The face may contain sap, small streaks, pin worm

holes, burls, slight imperfections in working, and small tight knots which do not average more than one to every 3 feet. Bundles to be 2 foot and up. Average length 3¾ feet.

No. 1 COMMON.—Shall be of such nature that will lay a good residential floor and may contain varying wood characteristics, such as flags, heavy streaks and checks, worm holes, knots and minor imperfections in working. Bundles to be 2 foot and up. Average length 3 feet.

No. 2 COMMON.—May contain sound natural variations of the forest product and manufacturing imperfections. The purpose of this grade is to furnish an economical floor suitable for homes, general utility use, or where character marks and contrasting appearance is desired. Bundles to be 1¼ foot and up. Average length 2½ feet.

1¼ SHORTS.—Pieces 9 to 18 inches long are to be bundled together and designated as 1¼′ Shorts. Pieces grading No. 1 Common, Select and Clear to be bundled together and designated No. 1 Common & Better with pieces grading No. 2 Common bundled separately and designated as such. Although pieces 6″ under and only 3″ over the nominal length of the bundle may be included, the pieces must average 1¼′ which is achieved through the natural preponderance of longer lengths.

Standard Thicknesses and Widths

$\frac{25}{32}$″ thickness; widths 1½″ face, 2″ face, 2¼″ face, and 3¼″ face.
⅜″ thickness; width 1½″ face and 2″ face.
½″ thickness; width 1½″ face and 2″ face.
Above tongue and groove and end matched.

Square Edge Strip Flooring

Grades as shown above but bundling and lineals as follows: $\frac{5}{16}$x2″, $\frac{5}{16}$x1½″, $\frac{5}{16}$x1⅓″, $\frac{5}{16}$x1¼″, $\frac{5}{16}$x1⅛″, $\frac{5}{16}$x1″, $\frac{5}{16}$x⅞″.
Also made rough back in $\frac{11}{32}$x2″ and $\frac{11}{32}$x1½″.

CLEAR.—Bundled 2 feet and up. Average length 5½ feet.

SELECT.—Bundled 2 feet and up. Average length 4½ feet.

No. 1 COMMON.—Bundled 2 feet and up. Average length 3½ feet.

No. 2 COMMON.—May contain defects of all characters, but will lay a serviceable floor.
Bundles to be 1¼ feet and up. Average length 2½ feet.
All faces shown above in $\frac{5}{16}$″ square edge are finished $\frac{1}{64}$″ over face.

FINISHED SIZES	$\frac{25}{32}$x2$\frac{1}{4}$"	$\frac{25}{32}$x1$\frac{1}{2}$"	$\frac{3}{8}$x1$\frac{1}{2}$"
Clear Plain White	$250.00	$180.00	$185.00
Clear Plain Red	260.00	185.00	190.00
Select Plain White	245.00	175.00	185.00
Select Plain Red	250.00	180.00	190.00
No. 1 Common White	225.00	150.00	170.00
No. 1 Common Red	230.00	155.00	175.00
No. 2 Common 2' & Lgr.	180.00	110.00	50.00
No. 1 Com. and Btr. Shts. 9-18"	150.00	85.00	50.00
No. 2 Common Shorts 1$\frac{1}{4}$'	100.00	50.00	30.00
COUNTED	1x3	1x2$\frac{1}{4}$	1x2
Pieces to Bundle	NESTED	NESTED	24
Weight per 1,000 ft. in lbs.	2100	1900	1000
ADD to Floor Area for BM (5% Cutting Waste Included)	38$\frac{1}{3}$%	55%	38$\frac{1}{3}$%
For BM Multiply Bundle Length	3	3	4

Approximate Prices of Oak Flooring

Approximate prices per 1,000 ft. b.m. f.o.b. factory, Tennessee. For less than carload lots add $5.00 per 1000 ft. b.m.

Add freight from factory to destination, plus dealer's mark-up (25 to 40 percent).

Prefinished Hardwood Flooring

Measured Size Inches	Finished Size Inches	Add for Waste Per Cent	To Obtain Quantity of Flooring Required Multiply Area By	No. Ft. Flooring Required for 100 Sq. Ft. Floor
1x4	$\frac{25}{32}$x3¼	23½	1.235	123½
1x3½	$\frac{25}{32}$x2¾	27½	1.275	127½
1x3	$\frac{25}{32}$x2¼	33⅓	1.333	133⅓
1x3	½x2½	20	1.20	120
1x2½	½x2	25	1.25	125
1x2½	⅝x2	25	1.25	125

Grading Rules on Prefinished Hardwood Flooring

OAK

White and Red Oak to be separated in each grade. Grades are established after the flooring has been sanded and finished.

PRIME GRADE: Face shall be selected for appearance after finishing, but sapwood and the natural variations of color are permitted. Minimum average length 4′. Bundles 2′ and longer.

STANDARD GRADE: Will contain sound wood characteristics which are even and smooth after filling and finishing and will lay a sound floor without cutting. Minimum average length 3′. Bundles 1¼′ and longer.

STANDARD AND BETTER GRADE: A Combination of Prime and Standard to contain the full product of the board except that no pieces are to be lower than Standard Grade. Minimum average length 3½′. Bundles 1¼′ and longer.

TAVERN GRADE: Shall be of such nature as will make and lay a serviceable floor without cutting, but purposely containing typical wood characteristics, which are to be properly filled and finished. Minimum average length 2½′. Bundles 1¼′ and longer.

BEECH AND PECAN

(Will be furnished only in a combination grade of Tavern and Better)

TAVERN AND BETTER: A combination of Prime, Standard, and Tavern to contain the full product of the board, except that no pieces are to be lower than Tavern Grade. Minimum average length 3′. Bundles 1¼′ and longer.

GENERAL RULES

(All Species)

Hardwood flooring is bundled by averaging the lengths. A

bundle may include pieces from 6 inches under to 6 inches over the nominal length of the bundle. No piece shorter than 9 inches admitted.

The percentages under 4 feet referred to apply on total footage in any one shipment of the item.

¾ inch allowance shall be added to the face length when measuring the length of each piece of flooring.

Flooring shall not be considered of standard grade unless the lumber from which the flooring is manufactured has been properly kiln dried.

Approximate Prices of Prefinished Hardwood Flooring

Factory finished and bevel edge. Approximate prices per 1,000 ft. b.m. f.o.b. factory, Tennessee. For carload lots, deduct $5.00 per 1,000 ft. b.m.

Add freight from factory to destination, plus dealer's mark-up.

Kind of Flooring	Size of Flooring in Inches		
	25/32 x 3¼	25/32 x 2¼	½ x 2
Prime White Oak	$255.00	$240.00	$230.00
Prime Red Oak	260.00	245.00	235.00
Standard White Oak	238.00	223.00	210.00
Standard Red Oak	240.00	225.00	215.00

Laying and Finishing Wood Floors

The following pages contain detailed itemized costs of laying and finishing all kinds of soft and hardwood floors.

In the larger cities there are carpenters who make a specialty of laying and finishing floors and they seldom do any other kind of work. Due to their long experience, they not only do a better job but accomplish more work per day than the average carpenter and they expect to be paid accordingly. For this reason costs are given for floors laid and finished by both carpenters and floorlayers.

Another reason some floorlayers will lay more floors than carpenters is because they do not nail the flooring 8" or 16" on centers but will nail at every other bearing unless watched continually.

Some floorlayers agree to lay and finish floors at a certain price per sq. ft., and when taken on this basis the men usually work harder than when paid by the day. An allowance of 25% should be added to all floorlayers' time to provide for this bonus.

Costs are given on two classes of workmanship. The first or Ordinary Workmanship includes the grade of work found in moderate priced homes, apartments, stores, etc., where the floorlaying permits of some hammer marks and is not a "bang-

up" job in every respect. Considerable savings can be obtained by laying the strip flooring all the way through prior to the erection of partitions.

First Grade Workmanship includes all classes of high class buildings where the best in workmanship is required, with all flooring closely driven up, laid free from hammer marks and with all nails set.

Labor Laying 100 Sq. Ft. of Hardwood Floors

Description of Work Ordinary Workmanship	Laying Floors		
	Sq. Ft. Laid 8-Hr. Day	Carp. Hours	Labor Hours
$^{25}/_{32}$"x3¼" face softwood floors for porches, kitchens, factories, stores, etc.	400–500	1.8	0.6
$^{25}/_{32}$"x2¼" face Third Grade Maple, for warehouse, factory and loft building floors	375–425	2.0	0.6
$^{25}/_{32}$"x2¼" face Oak or Birch in residences, apartments, stores, offices, etc.	250–300	2.9	0.6
Same as above laid by experienced floorlayer	300–350	2.5	0.6
$^{25}/_{32}$"x1½" face Third Grade Maple for warehouse, factory and loft building floors	300–325	2.3	0.7
$^{25}/_{32}$"x1½" face Oak or Birch in residences, apartments, stores, offices, etc.	150–200	4.5	0.8
Same as above laid by experienced floorlayer	225–275	3.2	*0.8
First Grade Workmanship			
$^{25}/_{32}$"x2¼" face Oak or Birch in fine residences, apartments, hotels, stores and offices requiring first class workmanship free from hammer marks and with all nails set	200–225	3.8	0.6
Same as above laid by experienced floorlayer	225–250	3.3	0.6
$^{25}/_{32}$"x1½" face Oak or Birch, same class of work as described above	120–150	6.0	0.8
Same as above laid by experienced floorlayer	175–200	4.3	0.8

Labor Laying ⅜" or ½" Hardwood Flooring.—Figure same costs as given above for 25/32" flooring.

Setting Sleepers in Mastic on Concrete Floors.—A sound, fast, economical way to provide nailing for strip wood flooring installed over concrete subfloors is the sleeper-in-mastic method, used extensively in the construction of slab on grade houses.

Assuming concrete slab is smooth, level and damproofed to prevent moisture seepage, 2"x4" wood sleepers are laid flat in

Labor Laying 1,000 Ft. B.M. Soft and Hardwood Flooring

Description of Work	Ordinary Workmanship		
	Ft. B. M. Laid per 8-Hr. Day	Carp. Hours	Labor Hours
25/32"x3¼" face softwood floors for porches, kitchens, factories, stores, etc.	500–600	14.5	4
25/32"x2¼" face Third Grade Maple, used in warehouses, factory and loft buildings, etc.	500–575	15.0	4
25/32"x2¼" face Birch or Oak flooring in residences, apartments, stores, etc.	350–400	21.0	4
Same as above laid by experienced floorlayer	400–450	19.0	4
25/32"x1½" face Third Grade Maple, used in warehouses, factory and loft buildings, etc.	450–500	17.0	4
25/32"x1½" face Birch or Oak flooring in residences, apartments, store and office buildings, etc.	250–280	30.0	5
Same as above laid by experienced floorlayer	350–400	21.0	5
First Grade Workmanship			
25/32"x2¼" face Oak or Birch flooring in fine residences, apartments, hotels, stores and offices requiring first class workmanship, free from hammer marks and with all nails set	275-300	28	4
Same as above laid by experienced floorlayer	325–375	23	4
25/32"x1½" face Oak or Birch, same class of work as described above for 2¼" face flooring	175–225	39	5
Same as above laid by experienced floorlayer	275–300	28	5

hot or cold mastic and are immediately ready to receive strip flooring. Installation is as follows:

After priming concrete slab, hot or cold mastic is spread to a $\frac{3}{32}$" depth over the entire slab or in $\frac{1}{4}$" deep rivers along parallel lines in positions where sleepers are to be placed.

Wood sleepers should be straight, flat, dry, 2"x4" lumber in random lengths from 18" to 48". For best results, sleepers should be treated with an approved non-creosote wood preservative. Lay sleepers in mastic, flat side down, in staggered rows on 12" centers at right angles to direction of flooring. Ends should overlap 4" and end joints should be staggered by alternating short and long lengths. Leave 1" clearance between sleepers and all vertical surfaces to allow for normal expansion.

Laying strip wood flooring over sleepers in mastic should follow the same general procedure as for over wood subfloors with the following additional precautions:

Use end-matched flooring only.

Individual strips of flooring should span at least two sleeper spacings, with no adjacent joints occurring in the same spacing.

Flooring strips passing over sleeper laps should be nailed to both sleepers.

Material coverages and approximate prices are as follows:

Asphalt primer, 200 to 400 sq. ft. per gal., depending upon porosity of concrete surface. Price 70 cts. per gal.

Hot mastic, 25 sq. ft. per gal. Price 55 cts. per gal.

Cold mastic, 40 to 50 sq. ft. per gal. Price 95 cts. per gal.

For average size rooms, 100 sq. ft. of floor area will require 120 to 135 lin. ft. or 80 to 90 ft. b.m. of 2"x4" wood sleepers.

Under ordinary conditions, a floorlayer should prime concrete floor, spread mastic and place wood sleepers at the rate of 100 sq. ft. per hour.

Flooring Contractor's Overhead Expense and Profit.—When the installation and/or finishing of wood floors is sublet to a flooring contractor, it will be necessary to add for overhead expense, workmen's compensation insurance, old age benefit tax, trucking and profit. This will vary with the size of the job, conditions, etc., but may run from 25 to 40 percent of the actual job cost.

Sanding Wood Floors by Machine

Practically all wood floors today are sanded and finished by machine and the cost varies, with the kind of flooring, whether old or new work, class of workmanship, size of rooms, etc.

The floors are first sanded with a floor sanding machine and then the edges are finished, using a disc type edging machine, which is capable of sanding up to the base shoe or quarter round.

The class of workmanship or number of operations governs production and cost but where just an ordinary grade of workmanship is required in average size rooms in houses, apartments, offices, etc., a good machine and operator should finish and edge 800 to 900 sq. ft. per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Machine expense		$.....	$.....	$1.50	$1.50*
Abrasive paper		.....	.....	1.00	1.00
Electric current		.....	.....	.25	.25
Operator-finisher	1	.....	.....	6.75	6.75
Cost per 100 sq. ft.	1		$.....		$9.50
Cost per sq. ft.			.....		.095

When used in store rooms, auditoriums and other large floor areas, a machine and operator should finish and edge 1,000 to 1,250 sq. ft. of new floor per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Machine expense	0.75	$.....	$.....	$1.50	$1.13*
Abrasive paper		.....	.....	1.00	1.00
Electric current		.....	.....	.20	.20
Operator-finisher	0.75	.....	.....	6.75	5.11
Cost per 100 sq. ft.	0.75		$.....		$7.44
Cost per sq. ft.					.074

Surfacing Floors by Machine, First Grade Workmanship.—In residences, apartments, hotel, store and office buildings, etc., where first grade workmanship is required, eliminating all irregularities and waves in the floor, about four cuts are necessary; first with No. 1½ or 2 grit sandpaper, then with No. ½ or 1 grit paper and the last two cuts with No. 0 paper.

On work of this kind an experienced operator should finish and edge 400 to 500 sq. ft. of floor per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Machine expense	1.75	$.....	$.....	$1.50	$ 2.63*
Abrasive paper		.....	.....	1.20	1.20
Electric current		.....	.....	.45	.45
Operator-finisher	1.75	.....	.....	6.75	11 82
Cost per 100 sq. ft.	1.75		$.....		$16.10
Cost per sq. ft.					.161

Resurfacing Old Floors by Machine.—When resurfacing old

*Includes rental on machine or depreciation, repairs, maintenance, trucking, etc., depending upon size of job.

wood floors, including the removal of old varnish, dirt, grease spots, etc., the cost will vary with the condition of the old floors. This variation will run from 300 to 1,000 sq. ft. per 8-hr. day and should be determined by the estimator after examining the old floors.

Cost of operating machine one hour will run as follows:

	Hours	Rate	Total	Rate	Total
Machine expense	1	$.....	$.....	$1.50	$1.50*
Abrasive paper		.....	.....	1.20	1.20
Electric current		.....	.....	.25	.25
Operator-finisher	1	.....	.....	6.75	6.75
Cost per hr.	1		$.....		$9.70
Cost per sq. ft. (300 sq. ft. per 8-hr. day)			.....		.258
Cost per sq. ft. (500 sq. ft. per 8-hr. day)			.....		.155
Cost per sq. ft. (750 sq. ft. per 8-hr. day)			.....		.103
Cost per sq. ft. (1,000 sq. ft. per 8-hr. day)			.....		.078

There is little or no difference in resurfacing an old floor or surfacing a new one except that under normal conditions one extra cut with a special open-faced abrasive is usually necessary to remove old varnish or paint.

Base Price List of Floor Surfacing Abrasive Paper

For Electric Floor Surfacing Machines

Full 50-Yard Rolls—Silicon Carbide Abrasive—Heavy Paper Backing.

Grit	Width in Inches 8"	12"
00	$19.03**	$28.30**
0	20.86	30.99
½	24.03	35.75
1	27.21	40.50
1½	30.62	45.63
2	34.28	51.12
2½	37.82	56.36
3	41.36	61.85
3½	43.03	64.47
4	43.03	64.47
4	48.28	73.27

Combination cloth back-paper reinforced with cloth is designed especially for sanding old varnished or shellacked floors. The advantage of this material, in addition to the cloth rein-

*Includes rental on machine or depreciation, repairs, maintenance, trucking, etc., depending upon size of job.

**All prices subject to quantity purchase discounts.

forcement, is the open coat of the cutting abrasive which prevents gumming on old floor work.

Chart for Floor Surfacing Operations

The following chart gives the proper abrasives or grits for surfacing all classes of wood floors:

Kind of Floors	Operation	Floor Conditions	Proper Grit
NEW FLOORS			
Oak, Maple and Close-Grained Hardwood Floors	Roughing	Ordinary Floors	2–2½
		Well Laid Floors	1½
		Very Uneven Floors	2½
		Very Hard Floors	2½
	Finishing	Ordinary Finish	½
		Fine Finish	0
		Extra Fine Finish	00
		Rough Finish	1
Parquet Floors	Roughing		1½
	Finishing	Semi-Finish	½
		Finishing	0
Cork Tile Floors	Roughing		1½
	Finishing	Semi-Finish	½
		Finishing	0
OLD FLOORS			
Resurfacing Old Floors—Soft and Hard Woods	Removing Varnish, Paints, etc.	Ordinary Conditions	3½
		Extra Heavy Coat Paint or Varnish	4
	Roughing	Ordinary Floors	2–2½
	Finishing	Ordinary Finish	½
		Fine Finish	0
		For Penetrating Sealer	00

Sanding Wood Floors

The cost of sanding floors will vary widely depending upon

whether the floors are new or old, the condition of the old floor, and the class of workmanship required.

The following specifications list the operations necessary to produce a first class job. Cheaper grades of workmanship will require less sanding and consequently less labor—and lower costs.

Sanding Old Wood Floors Laid in Strips.—The first operation is to remove the surface finish by sanding in the direction of the grain of the wood until all surface finish has been removed, using a drum type sanding machine, with extra heavy open coat sandpaper grit No. 3½ or 4.

The second operation is to remove the effects of the first operation and level the floor. Sand as in first operation, using same type machine with sharp sandpaper, grit No. 2 or 2½, to remove the effects of the coarse open coat sandpaper and level the floor surface.

The third operation is to use a spinner along the edges of the floor and hand scrape all corners where the machines could not reach. Use a No. 3½ or 4 grit paper and repeat, using No. 2 or 2½ grit paper.

The fourth operation is to sweep the entire floor to remove the coarse grits and abrasives left by the previous operations.

The fifth operation is to sand as in the first operation using the same type machine with No. 0 or No. ½ fine grit.

The sixth operation is the final smoothing of the edges. Sand as in third operation using same type of machine with fine sandpaper, grit 0 or ½.

After sweeping the entire floor clean it is ready for any kind of floor finish.

Sanding New Wood Floors Laid in Strips.—The first operation is to sand to a level surface. Sand in the direction of the grain of the wood until all the high edges or over-wood on the floor has been sanded off to a level surface, using a drum type sanding machine with No. 1½ or 2 grit sandpaper.

The second operation is to remove the scratch pattern of the first sanding. Sand in the direction of the grain of the wood until the scratch pattern of the first operation is eliminated using the same type sanding machine with No. 1 or ½ sandpaper. Frequent changes of sandpaper must be made to insure cutting rather than sliding over the surface.

The third operation is to use a spinner around the edges and scrape by hand where it is impossible to use the machine, without crossing the grain of the wood. Use same grits as on drum sander.

The fourth operation is to sweep the entire floor free from any

grit and abrasives and then sand in direction of the grain of the wood, using the drum type machine as in the first operation, with No. 0 sandpaper. Change the sandpaper frequently to insure cutting rather than sliding over the surface.

After sweeping the floor clean it is ready for any kind of floor finish.

Sanding Old Parquetry and Herringbone Wood Floors.—The first operation is to sand lengthwise of the room or at 45 degrees, using a drum type sanding machine with No. 3½ or 4 open coat grit, using a very light pressure on the drum.

The second operation is to remove the coarse marks of the first operation by sanding crosswise of the room using same type machine with No. 1 or 1½ grit. Change paper frequently to assure cutting rather than sliding over the surface. Then sand lengthwise of the room using No. ½ or No. 1 grit.

The third operation is to use a portable edging machine or hand scrape all places where the drum machine and edger cannot reach. Sweep the entire floor to remove coarse grits and abrasives left by previous operations.

The fourth operation is to use a large diameter rotary sanding machine across and then lengthwise of the room with No. ½ sandpaper to remove the cross marks of previous operations.

The fifth and final operation is to sweep the entire floor free from all grits, then sand using the large diameter rotary sander with No. 00 or No. 0 sandpaper, going over the floor once across and once lengthwise of the room.

After sweeping the floor clean it is ready for any kind of floor finish.

Finishing Hardwood Floors

The modern and approved method of finishing hardwood floors is to use wood sealers which are a special compound of ingredients blended so that they penetrate into the fiber and cells of the wood, sealing the pores with tough elastic materials, thereby building up a base resistance to water, dirt and stains. It wears only as the wood wears down.

Finishing Hardwood Floors in Natural Color.—Before finishing hardwood floors, they should be sanded as stated in previous paragraphs.

After the floor has been completely sanded and swept clean of all dust, a good grade of permanent penetrating seal should be applied. One such seal on the market is Pentra-Seal*. May be applied quickly with a brush, rag, mop, lamb's wool applicator or squeegee and does not leave brush or lap marks.

For an extra fast job, Fast-Drying Seal* is recommended. Ap-

*The American-Lincoln Corp., Toledo, Ohio.

ply a thin even coat and after it has become tack free remove the excess with a No. 2 steel wool pad. Sweep floor clean and apply a second coat in the same manner. Where a highly glossy finish is desired, apply a third coat and do not steel wool. This will remain on the surface, since the preceding coats have thoroughly filled every cell and/or pore, and result in a glossy surface finish.

The floor should now be given a final protective coat of a good grade of paste wax or Lustre Finish*. Paste wax should be applied manually and Lustre Finish can be put on with a mop. Two coats are recommended, followed by buffing with a mixed fiber brush.

Fast-Drying Seal is available in natural as well as seven decorator type colors. Coverage ranges from 400 to 450 sq. ft. per gallon for the first coat and 650 to 750 sq. ft. per gallon for the second coat. Price, Fast-Drying Seal Natural, about $7.00 per gal.; colors, slightly higher.

Coverage of Lustre-Finish is about 1,250 sq. ft. per gallon. Price, about $5.00 per gal.

Labor Finishing Wood Floors.—Assuming the floor has been sanded and is ready for the seal, an experienced man can finish about 1,000 sq. ft. of natural finish floor per 8-hr. day. Colored seal takes more time as the excess pigment must be removed by hand wiping.

Cost of 100 Sq. Ft. of Fast-Drying Seal* and Lustre Finish* Floor Finish on Wood Floors, Natural Color

	Hours	Rate	Total	Rate	Total
0.38 gal. Fast-Drying Seal		$.....	$.....	$7.00	$2.66
0.08 gal. Lustre Finish		.....	.....	5.00	.40
Floorlayer	0.8	.....	.....	6.75	5.40
Overhead expense and profit		.....	.....		2.11
Cost per 100 sq. ft.	0.8		$.....		$10.57
Cost per sq. ft.			.....		.106

WOOD BLOCK AND PARQUET FLOORING

Wood blocks are made of regular tongue and groove and end matched flooring so that each block has a continuous tongue along one side and end, and a continuous groove along the other side and end.

Each block is secured together on the back by metal splines which prevent the strips from coming apart.

The blocks may be obtained either finished or unfinished. The

*The American-Lincoln Corp., Toledo, Ohio.

finished blocks are completed at the factory and after being sanded are treated with a penetrating seal and are then waxed and polished. This gives a surface that will not crack or peel. The edges of the finished blocks are slightly beveled to accentuate the block effect and to make any small crack that may occur between the blocks unnoticeable. The unfinished blocks are furnished with square edges (unbeveled) to be finished after installation.

Wood blocks are furnished 9″x9″x$\frac{25}{32}$″ thick, consisting of 4 strips 2¼″ wide, or 9″x9″x½″ thick, consisting of 6 strips 1½″ wide. They may be obtained in the various grades of oak, beech, maple and walnut.

Wood block floors may be laid in mastic over wood subfloors or concrete.

Laying Wood Block Floors in Mastic Over Concrete.—The topping or finish coat of the concrete slab should be troweled with a wood float or leveling darby to a uniform level finish without projections or depressions and protected from injury until the concrete has thoroughly set.

Concrete subfloor shall be primed with one coat of asphalt priming paint and allowed to dry before laying blocks. Average covering capacity of primer 200 to 400 sq. ft. per gal. depending upon porosity of cement floor finish. Price $0.60 per gal. in 5-gal. cans.

Where concrete floors are in direct contact with the ground, below grade, or where there is not sufficient ventilation to prevent condensation, a membrane waterproofing shall be applied to the slabs, extending same up the sides of all walls, 4″ to 6″, according to manufacturer's specifications. Where wood blocks are to be laid in hot mastic, a hot application, two-ply membrane shall be applied. Where blocks are to be laid in cold mastic, a cold application one-ply polyethylene film shall be applied.

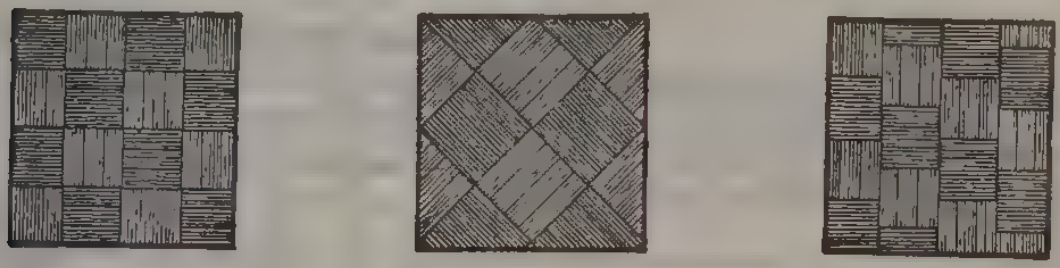
Installation of polyethylene film is as follows: after concrete surface is primed, cold mastic is applied at the rate of 80 to 100 sq. ft. per gal., into which polyethylene film is rolled, lapping joints 4 inches. Laps do not have to be sealed.

Blocks shall be laid to a level surface bedded in a suitable mastic without the use of nails or screws. One gallon of hot mastic shall be used to approximately each 25 sq. ft. of floor. Hot mastic costs from 60 cts. per gal. in 5-gal. cans to 52 cts. per gal. in 55 gal. drums, f.o.b. factory. Weight 9 lbs. per gal.

For cold applications, one gallon of cold mastic should be used for every 40 to 50 sq. ft. of floor. Cold mastic costs about 95 cts. per gal. in 5-gal. cans. Weight 10 lbs. per gal.

Expansion joints must be left around all edges of rooms according to manufacturer's specifications.

Labor Laying Wood Block Flooring.—When laying wood block floors in mastic in ordinary size rooms, such as residences, apartments, etc., an experienced floorlayer should lay 400 to 500 sq. ft. of floor per 8-hr. day, while in large spaces such as schools, auditoriums, gymnasiums, etc., an experienced floorlayer should lay 500 to 600 sq. ft. of floor per 8-hr. day. This applies to either finished or unfinished blocks, as the same care is required in laying either type of flooring. This does not include any time preparing or leveling old concrete floors, as this must be added extra if required.



Various Designs in Wood Block Flooring.

Where unfinished blocks are used, add for sanding and finishing.

Laying Wood Block Floors in Mastic over Other Surfaces.—Wood block flooring may also be laid in mastic over plywood or board subflooring, present wood floors, asphalt tile, etc., using the same general procedure as given above for over concrete, except subsurface will not require priming before applying mastic.

Subsurfaces must be sound, smooth, clean and dry—asphalt tile must be firmly bonded and in good condition—wood subflooring or present wood flooring may require re-nailing. Where installation is over square edged board subflooring, one layer of 15-lb. asphalt saturated felt should be laid in standard linoleum paste to keep mastic from seeping through joints.

Prices Per Square or Surface Foot of Wood Block Floors

It is not necessary to add for waste in laying wood block floors, except where cutting is necessary.

Owing to the variation in freight rates, dealer's mark-up, etc., it is practically impossible to give prices that will apply to all parts of the country. Dealer's mark-up will probably vary from 25 percent on large jobs to 40 percent on smaller installations, plus freight from factory to destination.

The following are approximate wholesale prices to which it will be necessary to add for freight and dealer's mark-up, and $0.01 per sq. ft. for L.C.L. shipments.

Factory Finished Wood Floor Blocks—Prices Per Square Foot

Grade	Unfinished	Prefinished		
	$\frac{25}{32}$x9x9	$\frac{25}{32}$x6$\frac{3}{4}$	$\frac{25}{32}$x7$\frac{1}{2}$	$\frac{25}{32}$x9,10$\frac{1}{2}$,1
Select & Better Quartered White	$0.50	$	$	$
Select & Better Quartered Red	.48			
Prime Grade—White or Red (9" Only)	.46	.45	.47	.50
Arabesque & Better	.40	.39	.41	.43
Arabesque		.32	.34	.36
Thrift Grade (Subject to accumulation)	.17	.19	.20	.21

Cost of 100 Sq. Ft. of 9"x9"x25/32" Wood Block Floors Laid in Mastic

	Hours	Rate	Total	Rate	Total
0.33 gal. asphalt primer..		$.....	$.....	$0.70	$ 0.23
100 sq. ft. wood blocks...		.....	.....	.48	48.00
4 gal. hot mastic.....		.....	.....	.52	2.08
Floorlayer	1.75	.....	.....	6.75	11.82
Cost per 100 sq. ft.....	1.75		$.....		$62.13
Cost per sq. ft.....			.....		.62

Where wood blocks are laid in cold mastic, reduce mastic quantity to 2 gals. per 100 sq. ft. and price at about 95 cts. per gal.

If wood blocks are laid over wood or asphalt tile surfaces, omit asphalt primer.

If block floors are laid in large spaces, such as auditoriums, etc., deduct $\frac{1}{4}$ to $\frac{1}{2}$ hr. floorlayer time per 100 sq. ft.

If sublet to a flooring contractor, add 15 percent for subcontractor's supervision and overhead expense and 10 percent for profit.

Add for membrane waterproofing, if required.

If unfinished blocks are used, change price of blocks and add for sanding and painters' finish.

Above costs do not include any allowance for preparing subfloor, if necessary.

Laminated Block Flooring.—Laminated Oak blocks are fabricated from 3-ply all oak plywood. Furnished in 9"x9"x½" size, factory finished.

Price f.o.b. factory: Grade A(Prime) 36 cts. per sq. ft.; Standard Grade 32 cts. per sq. ft.

Laminated block flooring is for mastic installation only and may be laid over any sound, smooth, clean and dry subfloor, using hot or cold mastic. General installation procedure is the same as for wood block floors given on previous pages, except that no allowance for expansion is necessary.

Labor costs for laying laminated block flooring should be about the same as for 9"x9"x25/32" wood blocks given on previous pages. Laminated flooring has increased in popularity due to its stability.

WOOD AND WIRE FENCE

Setting Wood Fence Posts.—When placing wire fence around the lots of 16 houses, it required 218 cedar posts, 5" in diameter and 7'-0" long, also 32 clothes posts, 7" in diameter and 10'-0" long.

After the holes had been dug, a man set 7 posts an hr. at the following labor cost per post:

	Hours	Rate	Total	Rate	Total
Carpenter	0.14	$.....	$.....	$6.75	$0.95

Treated pine posts and locust posts may also be used for fencing. Locust and cedar posts should be all heartwood.

Placing 2"x4" Top and Bottom Fence Rail Ready to Receive Wire.—The posts for these fences were spaced about 6'-0" apart and a 2"x4" top rail was nailed flatwise to the top of the post and a 2"x4" bottom rail was notched into the side of the post so that the wire could be stapled to it.

There was a total of 1,400 lin. ft. of fence or 2,800 lin. ft. of top and bottom rail. A carpenter placed rail for 110 lin. ft. of fence or 220 lin. ft. of single rail per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	7.3	$.....	$.....	$6.75	$49.28
Labor	0.9	.....	.....	5.00	4.50
Cost per 100 lin. ft. fence	8.2		$.....		$53.78
Cost per lin. ft. fence					.54
Cost per lin. ft. rail			.....		.27

Stringing Fence Wire.—Cyclone wire fencing in 42" rolls was used for these fences and was stapled to the top and bottom rails and posts about 4" on centers.

There were 1,400 lin. ft. of 42" wire fencing in the job and a

carpenter would string and staple about 280 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.9	$.....	$.....	$6.75	$19.58
Cost per lin. ft.			.....		.196

Setting Lally Columns in Basements.—In a group of brick houses, 3" iron columns were used to support the 6"x8" wood girders carrying the floor joists.

These columns were 3" in diameter and 7'-0" long, and a carpenter set, plumbed and braced 1 column an hr. at the following labor cost per column:

	Hours	Rate	Total	Rate	Total
Carpenter	1.0	$.....	$.....	$6.75	$6.75
Labor	0.3	.....	.....	5.00	1.50
Cost per column	1.3		$.....		$8.25

MISCELLANEOUS HARDWARE AND ACCESSORIES

Steel Area Walls and Gratings

Used around basement windows when first floor is at grade level. Made of 16-ga. and 20-ga. galvanized steel, with stiffening ribs and rounded tops. Attached to masonry walls by screws or bolts.

Size Width Depth	For Use with Basement Windows	Price Each 16 ga.	20 ga.
3'-2"x0'-11½"	15"x12"-2-Lt.	$4.50	$3.40
3'-2"x1'-5½"	15"x16"-2-Lt.	6.25	4.50
3'-2"x1'-11½"	15"x20"-2-Lt.	7.80	5.75

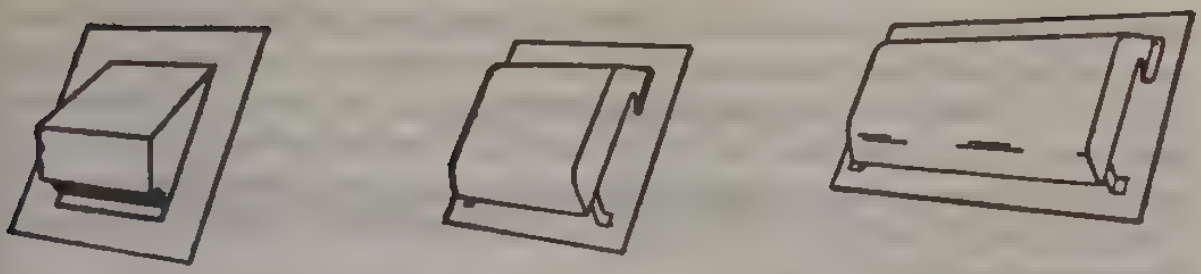
Steel gratings for use with above walls. Frames made of 1¼"x¼" steel bars with cross bars 1"x⅛" welded into one piece. Supports on the grating hold it flush with the top of the area wall. Price each painted.....$9.00

Metal Foundation Wall Ventilators

Brick Ventilators.—Made of aluminum exactly the size of a brick (2½"x4"x8"). The bottom edge is flanged both front and back to insure a positive mortar lock. Louvered face allows 13 sq. in. of free area. Screened back. Price each.....$1.25

Frame Ventilators.—Nailed to sheathing just above the foundation or to ends of joists spaced 16" on centers. Made of sheet aluminum, size 16"x8", providing 89 sq. in. of free area. Screened back. Price each.....$4.50

Concrete Block Ventilators.—Made of cast aluminum 16" wide x 8" high, providing 89 sq. in. of free area. Screened back. Price each.....$6.25



Metal Roof Ventilators

Metal Roof Ventilators

Metal roof ventilators provide air in the attic space under the roof. They are made of steel or aluminum and usually provide 18 to 75 sq. in. of free area.

Roof Opg. Inches	Free Area Sq. Inches	Price Each Aluminum
12x18	30	$4.35
15x20	50	5.25
16x16	65	10.00

Steel Clothes Chute Doors

Furnished in steel, white enameled, opening 9"x12".
Price each $6.00

Steel Access Doors

For access to piping or wiring installations. Furnished with a flanged frame that may be nailed to studs 16" on centers. Size of door 16"x24", overall size 17½"x25½".

Price each $11.50

Package Receivers

To be built into the wall to receive milk bottles and other small packages. Doors are 12¼"x12¼" and ½" thick with rounded corners. Equipped with nickel pull type catches. Inside door locks automatically when closed.

Wall Opening	Depth	Wall	Price
14¼"x11½"	6"	Frame	$20.50
14¼"x11½"	9"	Brick	21.00

ROUGH HARDWARE

While it is possible to include the cost of rough hardware, such as nails, screws, etc., in the material unit for each carpentry item figured, most contractors and estimators find it more convenient to make an allowance for this item at the end of the carpentry estimate based on the amount of lumber and other material in-

volved. The usual method of arriving at a rough hardware allowance is to total all the material in the carpentry estimate taking ft. b.m. of dimension lumber and boards, sq. ft. area of plywood, paneling, etc., and lin. ft. of grounds, furring strips, trim, etc., and then figure from 25 to 35 lbs. of nails per 1,000. The weight of nails multiplied by 16 cts. per lb. will give the rough hardware allowance required.

CHAPTER XVI

MILLWORK AND INTERIOR FINISH

When estimating the labor cost of erecting millwork and interior finish, it is advisable for the estimator to ascertain the grade of workmanship required by the architect or owner, as the quantity of work a man will perform per hour or per day will vary considerably with the grade of workmanship required.

The costs given on the following pages embody two distinct grades of workmanship. The grade termed Ordinary Work is by far the most common and is usually found in medium priced residences, cottages, apartment buildings, apartment buildings with stores underneath, factory and warehouse buildings, non-fireproof store, office and school buildings, and other buildings of this class.

The other grade, known as First Grade Workmanship, is usually required in finishing fine residences, high-class fireproof apartments, hotel, bank and office buildings, high grade store buildings, fireproof school and university buildings, courthouses, city halls, state capitols, post offices, and other buildings of this type. The interior finish in buildings of this class is usually selected birch, selected gumwood, plain or quarter-sawed oak, mahogany, walnut or other first-class hardwoods.

The Difference Between Ordinary and First Grade Workmanship.—There is considerable difference between the two grades of workmanship listed above and the estimator must be able to determine the grade required.

When placing wood base, chair rail or picture mold where just an ordinary grade of workmanship is required, the miters are not always perfect, the base does not hug the plastered wall closely at the top, which would not be tolerated where first grade workmanship is required. Also, the doors may not show the same margin at the sides and top, nails are not always set, and a close inspection of the trim will reveal some hammer marks.

Where first grade workmanship is required, the doors must be hung to show the same margin on all edges, the trim must be absolutely straight and plumb, all nails set and free from hammer marks, and with perfect fitting miters.

These same differences apply to the erection and installation of all classes of millwork and interior finish.

The Architectural Woodwork Institute publishes a manual of

"Illustrated Quality Standards" in which the work is divided into three grades: premium, custom and economy. Premium is the highest grade available in both material and workmanship, intended for the finest work. Sometimes it is used throughout an entire building, but most often only in selected spaces or items within a building. Custom is the middle or normal grade in both material and workmanship, and is intended for high quality regular work. Economy is the lowest grade and intended for work where price outweighs quality considerations.

An estimator may find references to these three grades in an architect's specification and, as this manual sets forth very exactly what is to be expected with both drawings and notes, he should have a copy of this booklet in his library. It is obtainable from the Architectural Woodwork Institute, Chesterfield House, Suite A, 5055 Chesterfield Road, Arlington, Va. 22206.

Methods of Estimating the Labor Cost of Erecting Mill Work and Interior Finish.—Different contractors use different methods of estimating the labor cost of erecting and setting millwork and interior finish, but the system generally used is to add a certain percentage of the cost of the millwork to cover the labor cost of erection. While this method is the easiest one known it does not produce the best estimates. Example: suppose you are estimating the cost of a building on which you receive 4 millwork bids ranging from $4,000.00 to $5,000.00. After receiving the bids you add the customary percentage to the lowest acceptable bid to take care of the labor cost of handling and erecting the millwork. This percentage usually runs from 40 to 50% of the cost of the millwork. Taking 40% of $4,000.00 gives $1,600.00 for labor to handle and erect all millwork and interior finish. Suppose a competitor received a bid for $3,500.00 from a mill which did not quote you. If your competitor added 40% to his bid, he would have only $1,400.00 to erect the same amount of millwork on which you figured $1,600.00.

Why this difference of 12½% on such a small item?

While this method saves a great deal of time and is almost universally used, it does not produce the most accurate estimates.

The only accurate method is to list each item separately; i.e., the number of lin. ft. of wood base, chair rail, picture mold, etc., the number of door jambs to set, the number of sash to fit and hang, together with the number of window openings to be cased or trimmed; the number of wardrobes, linen cases, vanity and kitchen units to set, etc. Estimating labor costs by this method produces more uniform and accurate estimates, reduces

risk to a minimum and enables the contractor to check actual and estimated costs during construction—but it does require a lot more work.

Placing Wood Base.—This cost will vary with the size of the rooms and whether 2 or 3-member base.

Where there are 55 to 60 lin. ft. of base in each room without an unusually large amount of cutting and fitting, a carpenter should place 125 to 150 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	5.8	$.....	$.....	$6.75	$39.15
Labor	1.0	.....	.....	5.00	5.00
Cost per 100 lin. ft.	6.8		$.....		$44.15
Cost per lin. ft.			.....		.44

If there are an unusually large number of miters to make, such as required in closets and other small rooms, increase the above costs accordingly.

A carpenter should place almost as many lin. ft. of 3-member base (consisting of 2 base members and a carpet strip), as 2-member base (consisting of one member and carpet strip), as it is much easier to fit a small top member against the plastered wall than it is to nail a wide piece of base so that it will fit snug against the wall and follow the irregularities in the plaster.

Where there are 50 to 60 lin. ft. of base in a room, a carpenter should place 110 to 130 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	6.7	$.....	$.....	$6.75	$45.23
Labor	1.0	.....	.....	5.00	5.00
Cost per 100 lin. ft.	7.7		$.....		$50.23
Cost per lin. ft.			.....		.50

First Grade Workmanship

In average size rooms, a carpenter should place 100 to 115 lin. ft. of 2-member base per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	7.4	$.....	$.....	$6.75	$49.95
Labor	1.0	.....	.....	5.00	5.00
Cost per 100 lin. ft.	8.4		$.....		$54.95
Cost per lin. ft.			.....		.55

Where 3-member wood base is used in average size rooms, a carpenter should place 85 to 100 lin. ft. (2 ordinary rooms)

per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	8.7	$.....	$.....	$6.75	$58.73
Labor	1.0	.....	.....	5.00	5.00
Cost per 100 lin. ft.	9.7		$.....		$63.73
Cost per lin. ft.					.64

On work of this class, the wood grounds should be straight, so that it will not be necessary to "force" the wood base to make it fit tight against the finished plaster wall.

Placing Wood Picture Molding.—Where just an ordinary grade of workmanship is required, a carpenter should place picture molding in 5 or 6 ordinary sized rooms per 8-hr. day. This is equivalent to 250 to 275 lin. ft. at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	3.0	$.....	$.....	$6.75	$20.25
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	3.5		$.....		$22.75
Cost per lin. ft.					.23

First Grade Workmanship

Where the wood picture molding must fit close to the plastered walls with perfect fitting miters, a carpenter should place molding in 4 to 5 ordinary sized rooms per 8-hr. day. This is equivalent to 175 to 200 lin. ft., at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	4.4	$.....	$.....	$6.75	$29.70
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	4.9		$.....		$32.20
Cost per lin. ft.					.32

If the picture molding is placed in fireproof buildings having tile or brick partitions, it will be necessary to place wood grounds for nailing the picture molding but in non-fireproof buildings the nails may be driven into the plaster, as the nails will obtain a bearing in the wood studs or wall furring.

Placing Wood Chair or Dado Rail.—In large rooms, long, straight corridors, etc., a carpenter should fit and place 275 to 300 lin. ft. of wood chair rail per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.8	$.....	$.....	$6.75	$18.90
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	3.3		$.....		$21.40
Cost per lin. ft.			.....		.21

In small kitchens, pantries, closets, bathrooms, etc., a carpenter will place only 160 to 180 lin. ft. of chair rail per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	4.7	$.....	$.....	$6.75	$31.73
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	5.2		$.....		$34.23
Cost per lin. ft.			.....		.34

First Grade Workmanship

Where first grade workmanship is required, a carpenter should place 200 to 225 lin. ft. of chair rail per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	3.8	$.....	$.....	$6.75	$25.65
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	4.3		$.....		$28.15
Cost per lin. ft.			.....		.28

In small rooms, such as kitchens, pantries, bathrooms, etc., requiring considerable cutting and fitting around medicine cabinets, wardrobes, kitchen cases, etc., a carpenter should place 120 to 135 lin. ft. of chair rail per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	6.3	$.....	$.....	$6.75	$42.53
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	6.8		$.....		$45.03
Cost per lin. ft.			.....		.45

Placing Wood Cornices.—Where 3 or 4-member wood cornices are placed in living rooms, reception rooms, dining rooms, etc., a carpenter should place cornice in one average sized room per 8-hr. day, which is equivalent to 50 to 60 lin. ft., and the labor cost per 100 lin. ft. would be as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	14.5	$.....	$.....	$6.75	$97.88
Labor	2.0	.....	.....	5.00	10.00
Cost per 100 lin. ft.	16.5		$.....		$107.88
Cost per lin. ft.			.....		1.08

First Grade Workmanship

Where it is necessary that the wood members fit the plastered walls and ceilings closely, with all miters true and even, two carpenters working together should complete one to one and a quarter rooms per day.

This is at the rate of 35 to 40 lin. ft. per 8-hr. day for one carpenter, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	21	$.....	$.....	$6.75	$141.75
Labor	2	.....	.....	5.00	10.00
Cost per 100 lin. ft.	23		$.....		$151.75
Cost per lin. ft.			.....		1.52

Placing Vertical Wood Panel Strips.—When vertical wood panel strips or "battens" are nailed to plastered walls to produce a paneled effect, a carpenter should place 22 to 28 pcs. (175 to 225 lin. ft.) per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	4.0	$.....	$.....	$6.75	$27.00
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	4.5		$.....		$29.50
Cost per lin. ft.			.....		.30

Placing Wood Strip Paneling.—Where panels are formed of wood molding 1½" to 2½" wide, making it necessary to cut and miter both ends of each panel strip, the lin. ft. cost will vary with the size of the panels and the amount of cutting and fitting necessary, as there is almost as much labor required on a panel 2'-0"x3'-0" as one 3'-0"x6'-0", although there are only half as many lin. ft. in the former as in the latter.

On small sized panels up to 2'-0"x4'-0", requiring 12 lin. ft. of molding, a carpenter should complete 9 to 11 panels, containing 110 to 135 lin. ft. of molding per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	6.5	$.....	$.....	$6.75	$43.88
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	7.0		$.....		$46.38
Cost per lin. ft.			.....		.46
Cost per panel	0.8		.....		5.52

On larger panels 3'-0"x5'-0" to 4'-0"x6'-0" in size, where each panel contains 16 to 20 lin. ft. of molding, a carpenter should complete 7 to 9 panels, containing 140 to 180 lin. ft. of molding per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	5.0	$.....	$.....	$6.75	$33.75
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	5.5		$.....		$36.25
Cost per lin. ft.			.....		.36
Cost per panel	1.1		.....		6.48

First Grade Workmanship

Where wood panel moldings are used over canvassed or burlap walls, with all strips plumb and level, fitting closely to the plastered walls with perfect fitting miters, a carpenter should complete 7 to 9 small panels, requiring 90 to 115 lin. ft. of molding per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	7.8	$.....	$.....	$6.75	$52.65
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	8.3		$.....		$55.15
Cost per lin. ft.			.....		.55
Cost per panel	0.8		.....		7.10

On larger panels 3'-0"x5'-0" to 4'-0"x6'-0" in size, where each panel contains 16 to 20 lin. ft. of panel molding, a carpenter should complete about 6 to 8 panels, containing 120 to 150 lin. ft. of molding per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	6.0	$.....	$.....	$6.75	$40.50
Labor	0.5	.....	.....	5.00	2.50
Cost per 100 lin. ft.	6.5		$.....		$43.00
Cost per lin. ft.			.....		.43
Cost per panel	1.2		.....		8.60

Placing Wood Ceiling Beams.—In buildings where built-up ceiling beams are used, the labor costs will vary according to the number of intersections of beams in each room and the length of the beams, as it is just as easy to erect a 12'-0" built-up beam as an 8'-0" one.

On average work, a carpenter should place 35 to 45 lin. ft. of built-up wood beams per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	20	$.....	$.....	$6.75	$135.00
Labor	3	.....	.....	5.00	15.00
Cost per 100 lin. ft.	23		$.....		$150.00
Cost per lin. ft.			.....		1.50

First Grade Workmanship

In the better class of buildings using wood ceiling beams, a carpenter should place 30 to 35 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	25	$.....	$.....	$6.75	$168.75
Labor	3	....	.....	5.00	15.00
Cost per 100 lin. ft.	28		$.....		$183.75
Cost per lin. ft.			.....		1.84

Nailing Wood Window Frames Together.—When wood window frames are sent to the job knocked down, it will require 1 to 1¼-hr. carpenter time to assemble and nail each frame together, at the following labor cost per frame:

	Hours	Rate	Total	Rate	Total
Carpenter	1.2	$.....	$.....	$6.75	$8.10

It will require 1¾ to 2¼ hrs. carpenter time to assemble and nail together, a double window frame up to 6'-0" wide and 5'-6" or 6'-0" high, at the following labor cost per frame:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50

Setting Single Wood Window Frames.—The labor cost of setting wood window frames will vary with the size of the frame, amount of bracing necessary and the distance they have to be carried or hoisted.

After a frame has been delivered at the job, it will require 10 to 15 minutes sorting frames and carrying them to the building and it will then require 20 to 30 minutes for 2 carpenters to set, plumb and brace each frame, which is at the rate of 8 to 12 frames per 8-hr. day.

The labor handling and setting each frame should cost as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40
Labor	0.2	.....	.....	5.00	1.00
Cost per frame	1.0		$.....		$6.40

Setting Double or Triple Window Frames.—It will ordinarily require 10 to 15 minutes for 2 men to carry a double or triple window frame from the stock pile to place where it is to be used and it will then require 30 to 35 minutes for 2 carpenters to set, plumb and brace the frame on the wall, at the following labor cost per frame:

	Hours	Rate	Total	Rate	Total
Carpenter	1.1	$.....	$.....	$6.75	$7.43
Labor	0.4	.....	.....	5.00	2.00
Cost per frame	1.5		$.....		$9.43

Window Cleaner's Bolts.—Window cleaner's bolts are usually required for windows above the first story unless both sides may be cleaned from the inside or the outside may be cleaned from a balcony or roof. This requirement does not apply to residential buildings of three stories or less.

These devices are made of brass or bronze and are furnished in sets, sufficient to equip one window, consisting of 4 bolts, 2 plates, 4 washers, 4 lock washers and 4 nuts and cost $4.00 to $5.00 per set depending upon size and style used. Window washer belts, if

specified to be furnished by the contractor, cost $40.00 to $50.00 each.

A carpenter should install 14 to 16 sets of window cleaner's bolts per 8-hr. day at the following labor cost per set:

	Hours	Rate	Total	Rate	Total
Carpenter	0.53	$.....	$.....	$6.75	$3.58

Labor Handling and Setting Complete Window Units.—When handling and setting complete window units consisting of frame, sash, balances, weatherstrips, etc., all installed complete, figure about ¼-hr. more than for handling and setting window frames of the same size.

Fitting Wood Sash.—When fitting wood sash for double hung windows, a carpenter should fit 24 to 28 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	0.6	$.....	$.....	$6.75	$4.05
Cost per single sash	0.3		.....		2.03

First Grade Workmanship

Where the sash must fit perfectly, with neither too much nor too little play, a carpenter should fit 18 to 22 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40
Cost per single sash	0.4		.....		2.70

Hanging Wood Sash.—Including the time required placing sash cord, chain and weights or counterbalances, a carpenter should hang 24 to 28 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	0.6	$.....	$.....	$6.75	$4.05
Cost per single sash	0.3		.....		2.03

First Grade Workmanship

Where care must be exercised to see that all sash work perfectly and the cord or chain is the exact length with the correct weights or counterbalances, a carpenter should hang 22 to 26 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	0.7	$.....	$.....	$6.75	$4.73
Cost per single sash	0.35		.....		2.37

Fitting and Hanging Wood Sash.—A carpenter should fit and hang, complete with sash cord, chain and weights or counterbalances, 12 to 14 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.2	$.....	$.....	$6.75	$8.10
Cost per single sash	0.6		.....		4.05

First Grade Workmanship

Where the sash must be fitted to have neither too much nor too little play and hung so they will work with ease and not be too loose, a carpenter should fit and hang (including sash cord, chain and weights or counterbalances), 10 to 12 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$.....	$.....	$6.75	$10.13
Cost per single sash	0.75		.....		5.07

Fitting Casement Sash.—A carpenter should fit 22 to 26 average size wood casement sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	0.7	$.....	$.....	$6.75	$4.73
Cost per single sash	0.35		.....		2.37

First Grade Workmanship

Where first class workmanship is required with all sash fitted to work easily without binding and hung so that each sash shows the same top, bottom and side margin, a carpenter should fit 14 to 18 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.0	$.....	$.....	$6.75	$6.75
Cost per single sash	0.5		.....		3.38

Hanging Casement Sash.—The labor cost of hanging casement sash will vary, depending on whether they are hung with 2 or 3 butts, style of butts used, etc.

Where the sash are hung using 2 butts per sash, a carpenter should hang 20 to 24 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	0.75	$.....	$.....	$6.75	$5.07
Cost per single sash	0.38		.....		2.54

First Grade Workmanship

In fine residences, apartments and other buildings where the casement sash must be hung without binding and to show the same margin at the top, bottom and sides, a carpenter should hang 12 to 14 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.2	$.....	$.....	$6.75	$8.10
Cost per single sash	0.6		.....		$4.05

Fitting and Hanging Casement Sash.—Under average conditions, a carpenter should fit and hang 10 to 13 single casement

sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.4	$.....	$.....	$6.75	$9.46
Cost per single sash	0.7		.....		4.73

First Grade Workmanship

Where casement sash must be fitted and hung to be neither too loose nor so tight as to cause binding when opening and closing and show the same margin between the sash and frame on all sides, a carpenter should fit and hang 7 to 9 single sash per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	2.2	$.....	$.....	$6.75	$14.85
Cost per single sash	1.1		.....		7.43

Fitting and Hanging Outside Window Blinds or "Shutters".—When fitting and hanging outside window blinds or "shutters" on medium priced residences, cottages, etc., a carpenter should fit and hang 7 to 8 pairs per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.1	$.....	$.....	$6.75	$7.43
Cost per single blind	0.55		.....		3.72

First Grade Workmanship

On the better class of buildings where more care must be used in fitting and hanging outside window blinds, a carpenter should fit and hang 5 to 6 pairs per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.4	$.....	$.....	$6.75	$9.46
Cost per single blind	0.7		.....		4.73

Interior Window Trim

The labor cost of placing interior window trim will vary considerably with the type of building, thickness of walls, style of trim or casing, etc. Frame buildings, stucco buildings, brick veneer buildings, etc., having walls 6" to 8" thick will not require inside wood jamb linings, as the wood window frames usually extend to the inside face of the plastered wall and the wood casings, window stools, aprons, stops, etc., are nailed directly to the wood frame.

Buildings having walls 10", 12", 16" or more in thickness will require a wood jamb lining to extend from the inside of the wood window frame to the face of the finished plaster. It will also require wood blocking and grounds to nail the jamb linings, window stools, aprons, etc.

The style of trim will affect labor costs considerably and for that reason costs are given on 4 distinct types of interior casings, as follows:

Style "A" consists of 1-member trim with either a mitered or square cut head or "cap". This is the simplest trim it is possible to use.

Style "B" consists of 1-member trim for sides and a built-up cap trim for window heads. Caps may be put together in the mill or assembled and put together on the job.

Style "C" consists of 2-member back-band trim, consisting of a one-piece casing with a back-band of thicker material.

Style "D" consists of any type of window trim that are assembled and glued together in the mill and set in the building as a unit.

The class of workmanship will also have considerable bearing on the labor costs, as in ordinary structures the casings are nailed to the frames or jamb linings and the trim may show some hammer marks but where First Grade Workmanship is required, the utmost care must be used in cutting and fitting all casings, miters, etc. All nails must be carefully driven and set, casings must show the same margin on all sides and must fit closely to plastered walls. In other words, it must be a first class job in every respect.

Labor Cost Erecting Interior Window Trim

Style Trim	Kind of Trim	No. Windows 8-Hr. Day	Carp. Hrs. per Window	Add for Wood Jamb Lining
"A"	Single Casing	7–8	1.0–1.1	0.6
"B"	Cap Trim*	5–7	1.1–1.6	0.6
"C"	Back-band Trim	5–6	1.3–1.6	0.6
"D"	Mill Assembled**	8–10	0.8–1.0	0.6
	First Grade Workmanship			
"A"	Single Casing	5–7	1.1–1.6	0.8
"B"	Cap Trim*	4–6	1.3–2.0*	0.8
"C"	Back-band Trim	4–5	1.6–2.0	0.8
"D"	Mill Assembled**	7–9	0.9–1.1	0.8

*For cap trim put together on job.

**Trim assembled and glued up in the mill.

On complicated window trim having recessed jamb linings and window trim that has both a casing and subcasing and a subcasing or panel under the stools, a carpenter will complete only about 1 window per 8-hr. day. This class of work is exceptional and is found only in high grade cabinet work.

Labor Setting Window Frames, Fitting and Hanging Wood Sash and Trimming Interior Window Openings Complete

The following table includes all labor required to set window frame, fit and hang wood sash, place jamb linings, stops, window stool, apron, interior casings, hardware, etc., for one complete single window opening.

Window Frames, Sash and Trim

Style Trim	Kind of Trim	No. Windows 8-Hr. Day	Hrs. per Window		Add for Wood Jamb Lining
			Carpenter	Labor	
"A"	Single Casing	2½–3	3.0	0.3	0.6
"B"	Cap Trim	2½–3	3.0	0.3	0.6
"B"	Cap Trim*	2¼	3.5	0.3	0.6
"C"	Back-band Trim	2¼	3.5	0.3	0.6
"D"	Mill Assembled**	2½–3	3.0	0.3	0.6
	First Grade Workmanship				
"A"	Single Casing	2	3.5	0.3	0.8
"B"	Cap Trim	2	3.5	0.3	0.8
"B"	Cap Trim*	2	4.1	0.3	0.8
"C"	Back-band Trim	2	4.4	0.3	0.8
"D"	Mill Assembled**	2¼-2½	3.3	0.3	0.8

*For cap trim put together on job.
**Trim assembled and glued up in the mill.

Setting Exterior Wood Door Frames

Size of Door Opening	No. Frames Set 8-Hr. Day	Carp. Hrs. per Frame	Add Hrs. for Transom
3′–0″x7′–0″	7–9	0.9–1.1	0.3
6′–0″x7′–0″	5–6	1.3–1.6	0.3
8′–0″x8′–0″	5–6	1.3–1.6	0.3
	First Grade Workmanship		
3′–0″x7′–0″	5–7	1.1–1.6	0.3
6′–0″x7′–0″	4–5	1.6–2.0	0.3
8′–0″x8′–0″	4–5	1.6–2.0	0.3

Setting Interior Wood Door Jambs

Size of Door Opening	Description of Jamb	No. Set 8-Hr. Day	Carp. Hrs. per Jamb	Add for Transom
3′–0″x7′–0″	Plain door jambs	8–10	0.8–1.0	0.6
3′–0″x7′–0″	Paneled door jambs	5– 6	1.3–1.6	0.6
7′–0″x7′–0″	Plain door jambs	5– 6	1.3–1.6	0.6
	First Grade Workmanship			
3′–0″x7′–0″	Plain door jambs	7– 9	0.9–1.1	0.6
3′–0″x7′–0″	Paneled door jambs	4– 5	1.6–2.0	0.6
7′–0″x7′–0″	Plain door jambs	4– 5	1.6–2.0	0.6

Interior Door Trim

The labor cost of placing interior door trim will vary with the type of trim or casings used and the class of workmanship. Costs are given on 4 different types of interior door trim, as follows:

Style "A" consists of 1-member casing with either a mitered

Labor Erecting Interior Door Casings and Trim

Style Trim	Kind of Trim	Size of Opening	No. Sides Trim per 8-Hr. Day	Carp. Hrs. per Side	Carp. Hrs. per Opening	Add for Transom†
"A"	Single Casing	3′–0″x7′–0″	14–16	0.5–0.6	1.0–1.2	0.6
"B"	Cap Trim	3′–0″x7′–0″	14–16	0.5–0.6	1.0–1.2	0.6
"B"	Cap Trim*	3′–0″x7′–0″	7– 8	1.0–1.1	2.0–2.2	0.6
"C"	Back-band Trim	3′–0″x7′–0″	9–10	0.8–0.9	1.6 1.8	0.6
"D"	Mill Assembled**	3′–0″x7′–0″	14–16	0.5–0.6	1.0–1.2	0.6
"A"	Single Casing	7′–0″x7′–0″	9–10	0.8–0.9	1.6–1.8	0.8
"B"	Cap Trim	7′–0″x7′–0″	9–10	0.8–0.9	1.6 1.8	0.8
"B"	Cap Trim*	7′–0″x7′–0″	5– 7	1.1–1.6	2.2–3.2	0.8
"C"	Back-band Trim	7′–0″x7′–0″	7– 8	1.0–1.1	2.0–2.2	0.8
"D"	Mill Assembled**	7′–0″x7′–0″	9–10	0.8–0.9	1.6–1.8	0.8
		First	Grade Workma	nship		
"A"	Single Casing	3′–0″x7′–0″	9–10	0.8 0.9	1.6–1.8	0.8
"B"	Cap Trim	3′–0″x7′–0″	9–10	0.8–0.9	1.6–1.8	0.8
"B"	Cap Trim*	3′–0″x7′–0″	5– 7	1.1–1.6	2.2–3.2	0.8
"C"	Back-band Trim	3′–0″x7′–0″	8– 9	0.9–1.0	1.8–2.0	0.8
"D"	Mill Assembled**	3′–0″x7′–0″	11–12	0.7–0.8	1.4–1.6	0.8
"A"	Single Casing	7′–0″x7′–0″	7– 8	1.0–1.1	2.0–2.2	1.0
"B"	Cap Trim	7′–0″x7′–0″	7– 8	1.0–1.1	2.0–2.2	1.0
"B"	Cap Trim*	7′–0″x7′–0″	5– 6	1.3–1.6	2.6–3.2	1.0
"C"	Back-band Trim	7′–0″x7′–0″	6– 7	1.1–1.3	2.2–2.6	1.0
"D"	Mill Assembled**	7′–0″x7′–0″	7– 8	1.0–1.1	2.0–2.2	1.0

*Cap trim put together by carpenters on the job.
**Trim assembled and glued together in the mill.
†Includes transom jambs, stops and casings but no transom sash.

or square cut head or "cap." This is the simplest trim it is possible to use.

Style "B" consists of 1-member trim for sides and a built-up cap trim for heads. Caps may either be put together in the mill or assembled and put together on the job.

Style "C" consists of 2-member back-band trim, consisting of a one-piece casing with a back-band of thicker material.

Style "D" consists of any type of door trim that is assembled and glued-up in the mill, ready to set in place as a unit.

The class of workmanship will have considerable bearing on the labor costs, as in ordinary workmanship the casings are nailed to the rough bucks or grounds and the trim may show some hammer marks but where First Grade Workmanship is required, the utmost care must be used in cutting and fitting all casings, miters, etc. All nails must be carefully driven and set and the casings must show the same margin on all sides of the jamb and trim must fit close to the plastered walls. In other words, it must be a first class job in every respect.

Fitting and Placing Stationary Transom Sash.—Where just an ordinary grade of workmanship is required, a carpenter should fit and place about 12 to 14 stationary transom sash per 8-hr. day, at the following labor cost per sash:

	Hours	Rate	Total	Rate	Total
Carpenter	0.6	$.....	$.....	$6.75	$4.05

First Grade Workmanship

Figure about 9 to 11 transom sash per 8-hr. day, at the following labor cost per sash:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40

Fitting and Hanging Hinged or Pivoted Transom Sash.—If the transom sash are hinged or pivoted, a carpenter should fit and hang 7 to 9 sash per 8-hr. day, at the following labor cost per sash:

	Hours	Rate	Total	Rate	Total
Carpenter	1.0	$.....	$.....	$6.75	$6.75

First Grade Workmanship

Figure about 5 to 7 hinged or pivoted transom sash per 8-hr. day, at the following labor cost per sash:

	Hours	Rate	Total	Rate	Total
Carpenter	1.3	$.....	$.....	$6.75	$8.78

Fitting and Hanging Wood Doors.—The labor cost of fitting and hanging doors will vary with the class of workmanship, weight of door, whether soft or hard wood, and upon the tools and equipment used, as there are power planes, hinge butt routers and lock mortisers that enable a carpenter to turn out

3 to 5 times as much work per day as where the doors are fitted and hung by hand. This must be considered when making up the estimate.

Where just an ordinary grade of workmanship is required, the doors do not always show the same margin at the top and sides, the screws are frequently driven instead of placed with a screw driver and in many instances the doors are "hinge-bound" so they will not open and close freely.

Where doors are fit and hung by hand, a carpenter should fit and hang 9 to 11 doors per 8-hr. day, (although some carpenters will fit and hang 14 to 16 doors per day), at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40

Labor Setting Jambs, Fitting and Hanging Doors, Placing Stops, Hardware and Casing One Door Opening Complete

Ordinary Workmanship

Size of Door Opening	Style Trim	Kind of Trim	Carp. Hrs. per Opening	Add for Transom†
3′–0″x7′–0″	"A"	Single Casing	3.1– 3.7	2.2
3′–0″x7′–0″	"B"	Cap Trim	3.1– 3.7	2.2
3′–0″x7′–0″	"B"	Cap Trim*	4.1– 4.7	2.2
3′–0″x7′–0″	"C"	Back-band Trim	3.7– 4.3	2.2
3′–0″x7′–0″	"D"	Mill Assembled**	3.1– 3.7	2.2
7′–0″x7′–0″	"A"	Single Casing	5.6– 6.5	2.8
7′–0″x7′–0″	"B"	Cap Trim	5.6– 6.5	2.8
7′–0″x7′–0″	"B"	Cap Trim*	6.2– 7.9	2.8
7′–0″x7′–0″	"C"	Back-band Trim	6.0– 6.9	2.8
7′–0″x7′–0″	"D"	Mill Assembled**	5.6– 6.5	2.8
		First Grade Workmanship		
3′–0″x7′–0″	"A"	Single Casing	5.5– 6.2	2.7
3′–0″x7′–0″	"B"	Cap Trim	5.5– 6.2	2.7
3′–0″x7′–0″	"B"	Cap Trim*	6.1– 7.6	2.7
3′–0″x7′–0″	"C"	Back-band Trim	5.7– 6.4	2.7
3′–0″x7′–0″	"D"	Mill Assembled**	5.3– 6.0	2.7
7′–0″x7′–0″	"A"	Single Casing	9.2–10.3	3.4
7′–0″x7′–0″	"B"	Cap Trim	9.2–10.3	3.4
7′–0″x7′–0″	"B"	Cap Trim*	9.8–11.3	3.4
7′–0″x7′–0″	"C"	Back-band Trim	9.4–10.7	3.4
7′–0″x7′–0″	"D"	Mill Assembled**	9.2–10.3	3.4

*Cap trim put together by carpenters on the job.

**Trim assembled and glued together in the mill.

†Above is for hinged or pivoted transom. For stationary transom deduct 0.4-hr.

On large production line jobs where power tools can be used to advantage and where the same class of work is performed using a power plane, an electric hinge butt router for door and jambs and an electric lock mortiser, a carpenter should fit and hang 18 to 22 doors per 8-hr. day, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	0.4	$.....	$.....	$6.75	$2.70

The above costs will vary with the ability of the carpenter and the job setup, as a power planer should plane off a door in 5 to 10 minutes; a hinge butt router should do all the way from 60 to 75 openings per 8-hr. day, while a lock router should mortise out for a lock in about ½-minute, after it has been set on the door. The labor handling the doors is the same for both hand and machine work.

For front door hardware, add 0.5-hr. for ordinary work and 1 to 2 hrs. for First Grade. Where cylindrical lock sets are used, deduct 0.2-hr. for ordinary work and 0.75 hr. for First Grade.

Where power planers, hinge butt routers and lock mortisers are used, deduct 0.4-hr. for single door and 0.8-hr. for double door openings, Ordinary Workmanship; For First Grade Workmanship, deduct 1.1-hrs. for single door and 2.2-hrs. for double door openings.

First Grade Workmanship

In the better class of buildings, the doors must show the same margin between the door and jamb at the top and sides, the hinges must be set even and flush with the jambs and the edge of the door and the doors must be free from "hinge binding" so they will fit well and work easily at the same time.

On this grade of work a carpenter should fit and hang about 4 doors per 8-hr. day, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50

Where power planers, hinge butt routers and lock mortisers are used, a carpenter should fit and hang 8 to 10 doors per 8-hr. day, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	0.9	$.....	$.....	$6.75	$6.08

Labor Installing Ready-Hung Door Units.—Ready-hung door units are used extensively in the construction of houses and apartments ranging from "economy" grade to middle class. They are available in two general types—knocked-down and completely assembled.

In the knocked-down package, jambs are cut to length; side jambs are notched for head jamb; one side jamb has half-hinges mortised and applied and the other is mortised to receive strike-

plate; door is prefit to correct size; door edges are eased; one door edge has the other half-hinges mortised and applied while the other is bored and mortised for the lock set. Stops are cut to length, but usually require on-the-job mitering.

Where knocked-down ready-hung door units are used, a carpenter should assemble and install 9 to 11 door units per 8-hr. day, at the following labor cost per unit:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40

In the completely assembled package, jambs are assembled, door is hung in place with all hardware applied and stops are mitered and tacked into place.

Where assembled ready-hung door units are used, a carpenter should install 18 to 22 units per 8-hr. day, at the following labor cost per unit:

	Hours	Rate	Total	Rate	Total
Carpenter	0.4	$.....	$.....	$6.75	$2.70

Fitting and Hanging Hardwood Accoustical Doors.—The labor cost of fitting and hanging hardwood acoustical doors is always figured on a first grade workmanship basis as they must be perfectly installed to insure their efficient operation.

Assuming a carpenter, experienced in hanging accoustical doors, is employed to do the work, the following production should be obtained:

Type of Door	Approximate Weight per Sq. Ft.	Carpenter Hours per Opening	Helper Hours per Opening
Hardwood Class 36	4 lbs.	6	3
Hardwood Class 41	7 lbs.	8	4

Fitting and Hanging Toilet Stall Doors.—A carpenter should fit and hang 9 to 11, $\frac{7}{8}$" or $1\frac{1}{8}$" toilet stall doors per 8-hr. day, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40

First Grade Workmanship

Where hardwood stall doors are used and carefully hung, a carpenter should fit and hang 7 to 9 doors per 8-hr. day, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$.....	$.....	$6.75	$6.75

Fitting and Hanging Heavy Wood Swinging Doors Up to 4'-0"x8'-0".—When hanging heavy wood swinging doors, such as used in garages, stables, mill and factory buildings, etc., where the doors are 3'-0" to 4'-0" wide and 7'-0" to 8'-0" high, it will

require about 4 to 4½-hrs. time to fit and hang one door or 8 to 9-hrs. per pair, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	4.3	$.....	$.....	$6.75	$29.03

Fitting and Hanging Heavy Wood Swinging Doors Up to 5'-0"x10'-0".—To fit and hang extra heavy wood swinging doors up to 5'-0"x10'-0"x2½" or 3" thick, will require about 4 to 5-hrs. time for 2 carpenters, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	9	$.....	$.....	$6.75	$60.75

Fitting and Hanging Heavy Wood Sliding Doors Up to 4'-0"x8'-0".—When fitting and hanging heavy wood sliding doors, such as used in garages, factories, etc., two carpenters working together should place tracks and hang one door complete in 3 to 3½ hrs. at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	6.5	$.....	$.....	$6.75	$43.88

To place track and hang a pair of double sliding doors for an opening up to 8'-0"x8'-0", will require 10 to 12 hrs. carpenter time, at the following labor cost per opening:

	Hours	Rate	Total	Rate	Total
Carpenter	11	$.....	$.....	$6.75	$74.25

The above does not include cutting or drilling in masonry walls to place bolts or anchors but is based on this work being done when the walls are built.

Fitting and Hanging Heavy Wood Sliding Doors Up to 10'-0"x10'-0".—To place track, fit and hang one sliding door up to 10'-0"x10'-0" in size and 2½" to 3" thick, will require 5 to 6 hrs. time for 2 carpenters, at the following labor cost per opening:

	Hours	Rate	Total	Rate	Total
Carpenter	11	$.....	$.....	$6.75	$74.25

The above does not include cutting or drilling masonry walls for bolts or anchors.

Fitting and Hanging Heavy Wood Sliding Doors Up to 12'-0"x18'-0".—To place track and hang one large door for an opening up to 12'-0"x18'-0", will require about 24 to 28 hrs. carpenter time, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	26	$.....	$.....	$6.75	$175.50

It will require 4 to 6 men to handle a door of this size.

Making and Setting Sliding Door Pockets.—Where sliding door pockets are made on the job for door openings up to 3'-0"x

7'-0", a carpenter should make the pocket, fit track and set the pocket in about 4 hrs. at the following labor cost:

	Hours	Rate	Total	Rate	Total
Carpenter	4	$.....	$.....	$6.75	$27.00

Where double doors are used and it is necessary to make and set 2 pockets, double the above costs.

Setting Sliding Door Pockets.—If sliding door pockets are sent to the job put together with track in place or steel pocket door T-frames are used, and the carpenters on the job set the pocket or steel frame ready to receive the door, it will require about 1 hr. carpenter time, at the following labor cost per opening:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$.....	$.....	$6.75	$6.75

If double sliding doors are used and it is necessary to set 2 pockets for each opening, double the above costs.

Fitting and Hanging Sliding Doors.—To fit an ordinary sliding door up to 3'-0"x7'-0", place hangers and hang the door complete, not including finish hardware, will require about 1 hr. carpenter time, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$.....	$.....	$6.75	$6.75

For double sliding doors, double the above costs.

Labor on Sliding Door Openings Complete with Pockets.—Where necessary to make the sliding door pocket, hang the track, set the pocket and fit and hang the door complete, exclusive of finish hardware, figure about 5 hrs. carpenter time, at the following labor cost per opening:

	Hours	Rate	Total	Rate	Total
Carpenter	5	$.....	$.....	$6.75	$33.75

For double sliding door openings, double the above costs.

If pockets are sent to the job with track fitted in place or steel pocket door T-frames are used, and the job carpenters set the box or steel frame and fit and hang the sliding door, it will require about 2 hrs. carpenter time per opening, exclusive of finish hardware, at the following labor cost per opening:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50

For double sliding door openings, double the above costs.

Labor Fitting and Hanging Sliding Wood Closet Doors.—When hanging and fitting wood closet doors that slide past each other without the necessity for pockets, a carpenter should

place track, attach hangers, fit and hang two doors complete for an opening 3′-0″ to 5′-0″ wide and 6′-8″ to 8′-0″ high in about 2 hours.

This does not include time setting door jambs and casing openings on two sides, as this should be added according to time given on previous pages.

The labor cost per opening should average as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50

Placing Wood Wainscot or Paneling.—The labor cost of placing wood paneling or wainscoting will vary with the height of the wainscot and the manner in which it is delivered, i. e., whether assembled or knocked down.

It takes nearly as long to place wood wainscoting 4′-0″ high as 7′-0″ high, as the top and bottom members are identical and the only difference is the height of the panels.

If the wood wainscot is put together in the mill and the carpenters on the job do what little fitting is necessary, set it against the walls and nail it to the grounds, a carpenter should place 12 to 18 lin. ft. of wainscot per 8-hr. day, at the following labor costs for the different heights:

Height of Wainscot	No. Sq. Ft. 8-Hr. Day	Carp Hrs. 100 Sq. Ft.
4′-0″	60-70	11-13
5′-0″	70-85	9-11
6′-0″	80-100	8-10
7′-0″	90-110	7- 9
8′-0″	95-115	7- 8

Placing Wood Wainscot or Paneling (Knocked Down).—If wood wainscot or paneling is sent to the job knocked down, making it necessary to assemble the pieces and put them together on the job, a carpenter should place top and bottom rails, cap and intermediate panels for 10 to 15 lin. ft. of wainscoting per 8-hr. day, at the following costs for the different heights:

Height of Wainscot	No. Sq. Ft. 8-Hr. Day	Carp Hrs. 100 Sq. Ft.
4′-0″	50-60	13-16
5′-0″	60-70	11-13
6′-0″	70-80	10-11
7′-0″	80-90	9-10
8′-0″	90-100	8- 9

Setting Cabinets and Cases.—When setting mill assembled cabinets and cases, such as used in the average residence or apartment building, it will require about ⅛ hr. carpenter time for

each sq. ft. of cabinet face area at the following labor cost p sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.16	$.....	$.....	$6.75	$1.09

A carpenter should fit and hang, complete with pulls ar catches, 15 to 17 flush case doors per 8-hr. day, at the followir labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	0.5	$.....	$.....	$6.75	$3.38

For lip case doors, not requiring fitting, a carpenter shou install, complete with pulls and catches, 30 to 34 doors per 8-h day, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	0.25	$.....	$.....	$6.75	$1.69

First Grade Workmanship

In the better class buildings where cases, wardrobes, cabinet etc., are used and it is necessary to scribe and fit them again the plastered walls or run a small molding to conceal join between cases and plastered walls, it will require about ⅓ h carpenter time for each sq. ft. of cabinet face area at the followir labor cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.33	$.....	$.....	$6.75	$2.25

A carpenter should fit and hang, complete with pulls an catches, 11 to 13 flush case doors per 8-hr. day, at the followin labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	0.67	$.....	$.....	$6.75	$4.50

Setting Factory Assembled and Finished Kitchen Cabinets.—When setting factory assembled and finished kitchen cabinet such as used in the average apartment or residence, it will requi about 0.1-hr. carpenter time for each sq. ft. of cabinet face area the following labor cost per sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.1	$.....	$	$6.75	$0.68

First Grade Workmanship

In better class apartments and residences where a high cla job of installation is required it will take about ⅛-hr. carpente time for each sq. ft. of cabinet face area at the following labor co per sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.16	$.....	$.....	$6.75	$1.09

Setting Wood Fireplace Mantels.—If wood fireplace mante are factory assembled, merely requiring fitting and setting, carpenter should install 2 to 3 mantels per 8-hr. day at the follow ing labor cost per mantel:

	Hours	Rate	Total	Rate	Total
Carpenter	3.2	$.....	$.....	$6.75	$21.60
Labor	1.0			5.00	5.00
Cost per mantel	4.2		$.....		$26.60

Fitting and Placing Closet Shelving.—A carpenter should fit and place 115 to 135 sq. ft. of closet shelving per 8-hr. day including setting of shelf cleats at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	6.4	$.....	$.....	$6.75	$43.20
Cost per sq. ft.					.43

Installing Hanging Rods in Closets.—A carpenter should install about three hanging rods, including supports, per hr. at the following labor cost per rod:

	Hours	Rate	Total	Rate	Total
Carpenter	0.33	$.....	$.....	$6.75	$2.25

Setting Metal Medicine Cabinets.—A carpenter should set 10 to 12 average size medicine cabinets per 8-hr. day at the following labor cost per cabinet:

	Hours	Rate	Total	Rate	Total
Carpenter	0.75	$.....	$.....	$6.75	$5.07

Setting Bathroom Accessories.—In an 8-hr. day a carpenter should locate and set 30 to 34 bathroom accessories, such as towel bars, soap dishes, paper holders, etc. at the following labor cost per accessory:

	Hours	Rate	Total	Rate	Total
Carpenter	0.25	$.....	$.....	$6.75	$1.69

Installing Chalkboards, Corkboards and Accessories.—Installation of chalkboard, according to manufacturer's instructions, is as follows:

Before starting, all grounds should be in place and final coat of finish should be thoroughly dry.

Chalkboard should be set so that all edges will be adequately covered by trim moldings. The writing surface should be plumb and in a true plane with ¼-in. clearance on all sides. Chalkboard panels should be nailed at the top edges only and the balance secured to the wall with an even coat of spotting cement.

Two carpenters working together should install 125 to 150 sq. ft. of chalkboard per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	11	$.....	$.....	$6.75	$74.25
Cost per sq. ft.					.74

Installation of corkboard is similar to that of chalkboard except nailing is eliminated. The labor cost of installing corkboard is approximately the same as for chalkboard.

Installation of aluminum trim moldings in conjunction with

chalkboards and corkboards may be accomplished either wit exposed wood screws or with concealed snap-on clips. A carpente should install 90 to 110 lin. ft. of molding per 8-hr. day at th following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	8	$.....	$.....	$6.75	$54.00
Cost per lin. ft.					.54

Labor Placing Finish Hardware

Description of Work	No. Set per 8-Hr. Day	Carp. Hrs. Each
Rim locks or night latches, cheap work	20-24	0.3-0.4
Mortised locks in soft or hardwood doors, Ordinary Workmanship	12-16	0.5-0.7
Mortised locks in hardwood doors, First Grade Workmanship	6-8	1.0-1.3**
Cylindrical locks	17-23	0.3-0.05
Front entrance door locks, Ordinary Workmanship	6-8	1.0-1.3*
Front entrance cylinder locks in hardwood doors, First Grade Workmanship	4-5	1.6-2.0***
Panic bolts, First Grade Workmanship	2-3	2.7-4.0
Door closers, exposed	7-9	0.9-1.1
Door closers, concealed	2-3	2.7-4.0
Door holders	20-24	0.3-0.4
Sash lifts and locks, No. of windows	20-24	0.3-0.4
Cremone bolts for casement doors and windows	20-24	0.3-0.4
Kickplates, Ordinary Workmanship	8-10	0.8-1.0
Kickplates, First Grade Workmanship	6-8	1.0-1.3

*On this class of work the architect or owner must expect to ha more or less trouble with hardware because the time given is n sufficient to adjust lock and see that it operates properly, etc.

**On this grade of work the lock must be flush with the face of th door and must operate perfectly.

***This includes front door locks having fancy escutcheon plate knobs, knockers, etc.

Labor Placing Cabinet Hardware

Description of Work	No. Set per 8-Hr. Day	Carp. Hr Each
Surface butts	180-200	.040-.04
Offset butts	90 100	.080-.09
Elbow catches	90-100	.080-.09
Friction catches	90-100	.080-.09
Drawer and door pulls	140-150	.053 .05
Knobs	180 200	.040-.04
Rim latches	90 100	080-.09
Mortised locks	20-24	.3-.4

WOOD STAIRS

Framing and Erecting Wood Stairs of Unassembled Stock Material.—When framing and erecting ordinary wood stairs having closed stringers where the treads and risers are not housed out, it will require 3 to 4 hrs. carpenter time to lay out the work, cut out for treads and risers and place wood stringers for a flight of ordinary wood stairs up to 4′-0″ wide and 11′-0″ story height, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Carpenter	3.5	$.....	$.....	$6.75	$23.63

After the wood stringers are in place, it will require 2 to 3 hrs. carpenter time to place treads and risers for each flight of stairs (providing it is a plain box stair without nosings to form and without newels, balusters or handrail), at the following labor cost per flight:

	Hours	Rate	Total	Rate	Total
Carpenter	2.5	$.....	$.....	$6.75	$16.88

Figure 2 to 3 hrs. carpenter time to place 4″x4″ newels, 2″x4″ rails and 1″x2″ balusters for one side of this type stairs, at the following labor cost per flight:

	Hours	Rate	Total	Rate	Total
Carpenter	2.5	$.....	$.....	$6.75	$16.88

To lay out the work and erect the stairs complete, including plain wall hand rail secured by brackets (instead of newels, hand rails and balusters), figure 6 to 8 hrs. carpenter time, at the following labor cost per flight:

	Hours	Rate	Total	Rate	Total
Carpenter	7	$.....	$.....	$6.75	$47.25

For the above stair complete, including newels, handrail and balusters, one side, figure 7 to 10 hrs. carpenter time, at the following labor cost per flight:

	Hours	Rate	Total	Rate	Total
Carpenter	8.5	$.....	$.....	$6.75	$57.38

Erecting Wood Stairs Made in Shop.—Where wood stairs are made in the shop with stringers housed out to receive treads and risers, it will require 6 to 8 hrs. stair builder's time to lay out the work, set stringers, treads and risers (with plain wall rail attached to brackets), at the following labor cost per flight:

	Hours	Rate	Total	Rate	Total
Stair builder	7	$.....	$.....	$6.75	$47.25

If the stair consists of two short flights, having an intermediate landing platform between floors, it will require 10 to 12 hrs. stair builder's time to lay out work, place stringers, treads, risers and plain wall handrail, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Stair builder	11	$.....	$.....	$6.75	$74.25

Where a plain box stair (3'-0" to 4'-0" wide and 9'-0" t 10'-0" story height) with open stringers is used, it will requir 10 to 12 hrs. stair builder's time to lay out work, place stringers treads and risers (not including newels, balusters or handrail for each flight of stairs, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Stair builder	11	$.....	$.....	$6.75	$74.25

If the stairs have newels, wood handrail and balusters, ad 6 to 8 hrs. stair builder's time, at the following labor cost pe flight:

	Hours	Rate	Total	Rate	Total
Stair builder	7	$.....	$.....	$6.75	$47.25

Plain box stairs consisting of two short flights having a intermediate landing platform between stories will requir 6 to 8 hrs. stair builder's time to lay out the work, place string ers, treads and risers for each short flight of stairs, at th following labor cost per flight:

	Hours	Rate	Total	Rate	Total
Stair builder	7	$.....	$.....	$6.75	$47.25

To place newels, balusters and handrail on each short fligh of stairs will require about 4 hrs. stair builder's time, at th following labor cost per flight:

	Hours	Rate	Total	Rate	Total
Stair builder	4	$.....	$.....	$6.75	$27.00

The labor cost complete for two short flights of stairs, in cluding newels, handrails and balusters should cost as follow per story height:

	Hours	Rate	Total	Rate	Total
Stair builder	22	$.....	$.....	$6.75	$148.50

Erecting Wood Stairs Having Open Stringers.—Wood stair of the open stringer type having treads with a return nosin projecting beyond the face of the stringer, will require about 1 to 14 hrs. stair builder's time to lay out the work and pac stringers, treads and risers for one flight of stairs containin 16 to 18 risers, at the following labor cost per flight:

	Hours	Rate	Total	Rate	Total
Stair builder	13	$.....	$.....	$6.75	$87.75

If necessary to place newels, handrail and balusters, add abou 8 to 9 hrs. stair builder's time, at the following labor cost pe flight:

	Hours	Rate	Total	Rate	Total
Stair builder	8.5	$.....	$.....	$6.75	$57.38

If the stair consists of two short flights having an inter mediate landing platform between stories (each short fligl contains 8 to 10 risers), it will require about 8 to 9 hrs. stai

builder's time per flight or 16 to 18 hrs. per story, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Stair builder	17.0	$.....	$.....	$6.75	$114.75
Cost per short flight	8.5		.....		57.38

To set starting and landing newels, handrails and wood balusters will require 7 to 9 hrs. stair builder's time per flight or 14 to 18 hrs. per story, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Stair builder	16	$.....	$.....	$6.75	$108.00
Cost per short flight	8		.....		54.00

The above does not include carpenter time framing and erecting intermediate landing platform.

Placing Wood Handrail on Metal Balustrades.—A carpenter should place 45 to 55 lin. ft. of wood handrail on metal balustrades per 8-hr. day at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	16	$.....	$.....	$6.75	$108.00
Cost per lin. ft.					1.08

Placing Wood Handrail on Wall Brackets.—A carpenter should set brackets and install 65 to 70 lin. ft. of wall hung wood handrail per 8-hr. day at the following labor cost per 100 lin. ft.:

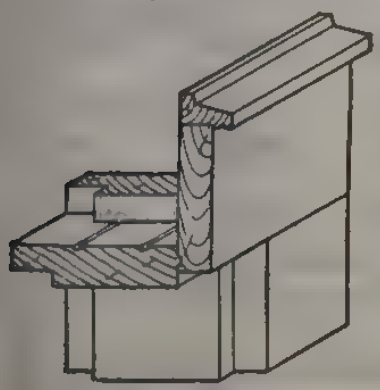
	Hours	Rate	Total	Rate	Total
Carpenter	12	$.....	$.....	$6.75	$81.00
Cost per lin. ft.					.81

MILLWORK AND INTERIOR FINISH

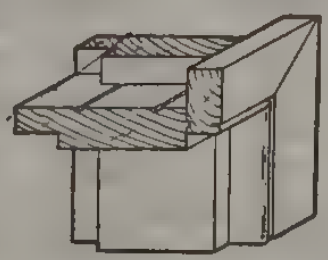
The prices given on the following pages covering Millwork and Interior Finish are for materials of stock sizes and design, of medium quality.

It is almost impossible to quote on special materials, as the prices vary greatly in different localities and among different mills, and are often contingent upon the amount of work the plant has on hand as well as the labor conditions in each locality.

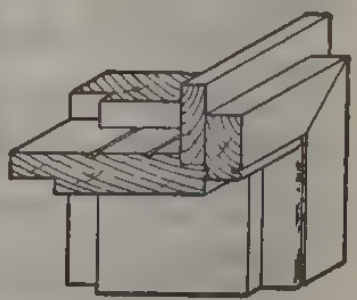
Always obtain definite prices from your mill before quoting.



Stud Wall Drip Cap Frame



Brick Wall Frame



Brick Veneer Wall Frame

Prices of Western Pine Exterior Door Frames

	Drip Cap		Masonry	
	4⅝"	5¼"	4⅝"	5¼"
2'-6"x6'-8"	$21.57	$22.20	$18.54	$19.11
2'-8"x6'-8"	22.08	22.74	18.87	19.44
2'-8"x7'-0"	22.83	23.52	19.65	20.22
3'-0"x6'-8"	23.19	23.88	19.08	19.65
3'-0"x7'-0"	23.88	24.60	19.86	20.46
4'-0"x6'-8"	25.59	26.37	20.40	21.00
5'-0"x6'-8"	27.72	28.56	21.33	21.96
6'-0"x6'-8"	30.57	31.50	22.44	23.13

Extras for Door Frames

6" jamb, add to 5¼"	$ 0.7
6¼"-10¼" jamb, add	10.5
Cutting down jamb width, add	.6
Rabbets other than 1⅜ or 1¾" add	1.8
Head and side casing to 3⅝" wide	3.7
Head and side casing to 4½" wide	4.9
Multiple door frames, per mullion	7.5

Exterior Jamb Sets, 1¾" Rabbeted-1 5/16" Thick.

4¾", 3'-0"x6'-8" solid	$7.5
4¾", 3'-0"x6'-8" finger joint	6.5
5¼", 3'-0"x6'-8" solid	9.0
5¼", 3'-0"x6'-8" finger joint	8.0

Door Frame Prices with Preglazed Sidelight One Side for 3'-0"x6'-8" Doors

Glass	With 1-1'-0" x 6'-8" S.L.		With 1-1'-4" x 6'-8" S.L.		With 1-1'-8" x 6'-8" S.L.	
	Drip Cap	Masonry	Drip Cap	Masonry	Drip Cap	Masonry
DSB-1 Lite	$ 52.23	$ 49.20	$ 52.74	$ 49.71	$ 53.37	$ 50.37
DSB & Flat Pan.	60.66	57.60	61.17	58.14	61.80	58.80
DSB & Raised Pan.	67.44	64.38	67.89	64.86	68.58	65.55
3 Light SSB	62.88	59.88	63.48	60.45	64.08	61.08
3 Light & Flat Pan.	71.22	68.22	71.82	68.79	72.42	69.42
3 Light & Raised Pan.	77.94	74.91	78.51	75.48	79.11	76.08

Also available in 4 and 5 light with or without flat or raised pan and with fluted, latticed rondel or lozenged, or insulating glas

Door Frame Prices with Preglazed Sidelights Both Sides for 3'-0"x6'-8" Doors

Glass	With 2-1'-0" x 6'-8" S.L.		With 2-1'-4" x 6'-8" S.L.		With 2-1'-8" x 6'-8" S.L.	
	Drip Cap	Masonry	Drip Cap	Masonry	Drip Cap	Masonry
DSB-1 Light	$ 88.53	$ 86.46	$ 89.52	$ 87.45	$ 90.87	$ 88.80
DSB & Flat Pan.	105.39	103.35	106.38	104.31	107.73	105.66
DSB & Raised Pan.	118.89	116.82	119.88	117.81	121.20	119.13
3 Light SSB	103.35	101.28	104.46	102.42	105.66	103.62
3 Light & Flat Pan.	116.25	114.18	117.36	116.40	118.56	116.52
3 Light & Raised Pan.	129.63	127.53	130.71	128.67	131.94	129.90

Interior Door Jambs

The following prices are for plain door jambs $\frac{3}{4}$"x5$\frac{3}{8}$". Side jambs are dadoed at top for head jambs. The prices are for jambs only, not including stops which must be added. Furnished knocked down.

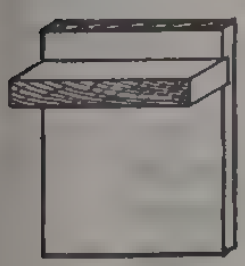
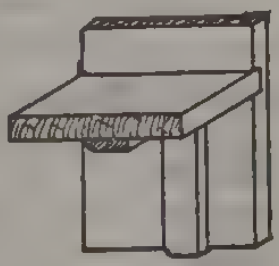
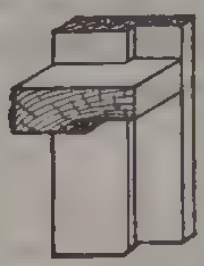
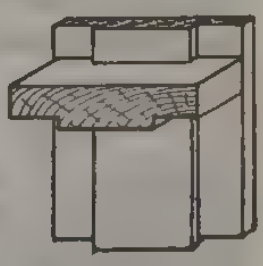
Price Per Set, Dadoed and Sanded, Not Including Stops

Size	Pond. Pine	Nat. Birch	Phil. Mahog.	Plain Oak
2'-8"x6'-8" or smaller	$ 8.00	$12.00	$ 9.50	$10.00
3'-0"x7'-0" or smaller	9.00	13.50	10.75	11.75
6'-0"x6'-8" or smaller	10.00	15.00	12.00	13.00

Add for Door Stops 7/16"x1$\frac{3}{8}$", Cut to Length

	Pond. Pine	Nat. Birch	Phil. Mahog.	Plain Oak
3'-0"x7'-0" or smaller	$0.95	$2.76	$1.20	$2.20
6'-0"x7'-0" or smaller	1.10	3.22	1.45	2.53

If door jambs are wanted put together in the mill, add $1.50 per set to the above prices.

Inside Rabbeted Door Jambs for 1$\frac{3}{8}$" or 1$\frac{3}{4}$" Doors

Single or double rabbet, size of jambs 1$\frac{3}{8}$"x5$\frac{3}{8}$"

Size in Inches	Price Per Lineal Foot Pond. Pine	Nat. Birch	Phil. Mahog.	Plain Oak
1$\frac{3}{8}$x5$\frac{3}{8}$	$0.70	$1.10	$0.60	$0.82

Door Jambs for Single or Double Sliding Doors

They are ¾"x3½" wide and are to be used where the studs are set flat for a wall 3½" thick.

Size of Opening	Pond. Pine	Nat. Birch	Phil. Mahog.	Plain Oak
3'-0"x7'-0" or smaller	$8.20	$12.70	$ 7.10	$ 9.70
6'-0"x7'-0" or smaller	9.80	14.25	8.10	11.10

Stock door casings per 100 lineal feet will cost $9.20 in Ponderosa pine, $11.50 in mahogany, and $19.75 in birch. Stops will run $4.30, $5.47 and $12.75 respectively.

Oak thresholds, 3⅝"x⅝" will run $23.40 per 100 ft. and oak sills, 1 5/16"x7¼" will run $90.00 per 100 ft. Pre-cut sills will run $2.75 for 2'-8" opening, $3.00 for 3' opening.

WOOD DOORS

Flush Veneer Slab Doors for Exterior Use

Furnished with water and weather resistant face veneers both sides of the door. For either interior or exterior use. V.G. Fir furnished with 3/16" face veneers for "V" grooves, if desired. All doors 1¾" thick.

Size	Plain Red Oak	Birch	Philippine Mahogany
2'-6"x6'-8"	$49.90	$49.90	$57.25
2'-8"x6'-8"	51.45	52.00	61.95
3'-0"x6'x8"	56.70	57.25	67.20
3'-0"x7'-0"	58.80	59.35	70.90

Extras for Altering Solid Core Flush Doors

For "V" grooves, add per groove	$ 1.50
For cutting in one square light, add	8.95
For one circle light, approx. 12" diam., add	21.55
For one circle light, approx. 18" diam., add	25.75
For one peek light, add	13.65
For one diamond light, add	13.65

White Pine Entrance Doors

Type	2'-8" x 6'-8" x 1¾"	3'-0" x 6'-8" x 1¾"
6 Panel Colonial	$26.00	$28.00
4 Panel & Light	29.00	31.00
4 Panel & 4 Light	30.00	32.00
X Buck & 9 Light Rect.	36.00	41.00
X Buck & 12 Light Diag.	47.00	52.00
X Buck & 9 Light-Dutch	42.00	45.00
X Buck & 12 Light-Dutch	54.00	57.00
12 Panel Spanish	61.00	—
21 Panel Spanish	—	66.00

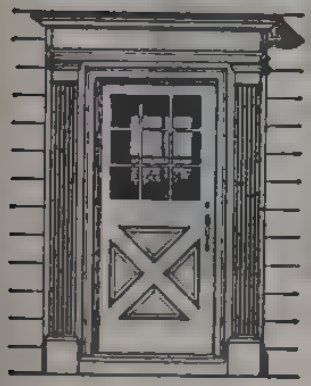
These doors can usually be purchased prehung in rabetted frames of standard widths with 1½ pair of butts, but no sill, lock or weatherstripping for about $40.00 extra.

Western Pine Colonial Front Entrances

"A"

"B"

"C"



"D"

"E"

"F"

Colonial Front Entrances

Exterior trim sets for front entrances are available; the price range is great, depending on depth of members, elaborateness and sharpness of carvings and flutings. One manufacturer offers trim resembling entrance "A" above at $125.00 in the deluxe model, $65.00 for a modified design. Trim such as doorways "C," "D" and "E," around $65.00. These may also be purchased as complete entrance sets with frames, thresholds and sidelights if desired.

Exterior wood doors are usually fitted with combination storm and screen units. These are usually of 1⅛" thick Ponderosa pine with aluminum wire. They run as follows for 6'-9" height:

	2'-6"	2'-8"	3'-0"
4 Light	$21.00	$21.50	$23.00
X Buck & 1 Light	—	25.00	26.50

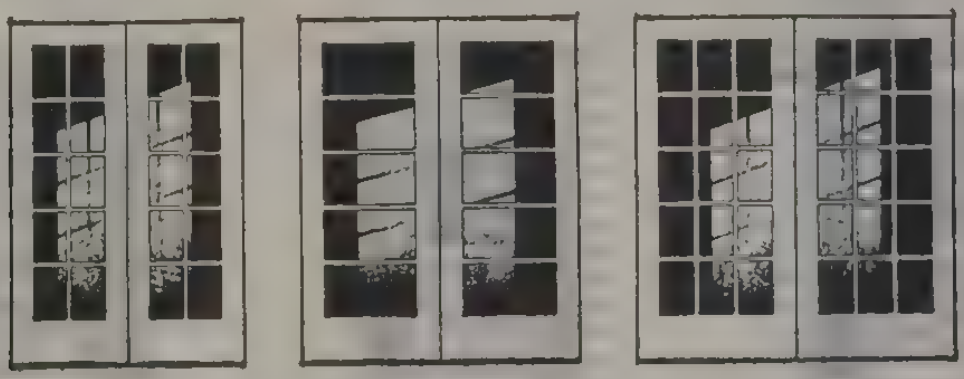
Combination doors are also available in aluminum, 1" thick for either 6'-8" or 7'-0" openings in various qualities.

Standard quality, 2'-6", 2'-8" & 3'-0" wide	$25.00
Deluxe quality, 2'-6", 2'-8" & 3'-0" wide	28.00
Deluxe quality with white finish, 3'-0" wide	36.00
X-Buck type with white finish, 3'-0" wide	45.00

Soft Wood French Doors

Made of clear Ponderosa pine. Stiles and top rails are 4¾" and bottom rails are 9⅝" overall with bead and cove sticking. Munts are ½" between glass. Wood stops or glazing beads are mitred and tacked in place.

Type	2'-6" x 6'-8"		2'-8" x 6'-8"		3'-0" x 6'-8"	
	1⅜"	1¾"	1⅜"	1¾"	1⅜"	1¾"
1 Light French	$24.00	$28.00	$24.00	$28.00	$26.00	$30.00
5 Light French	25.00	29.00	25.00	29.00	27.00	31.50
15 Light French	26.00	30.00	26.00	30.00	28.00	33.00



French Doors

Interior Hollow Flush Doors

Hollow flush doors are built-up over a hollow core instead c a solid core and are much lighter in weight than the solid cor doors, also less expensive.

For doors 1¾" thick, add $2.00 per door for smaller sizes an $2.25 per door for larger sizes.

Doors 1⅜" Thick Size	Plain Red Oak	Plain Birch	Phil. Mahog.
2'-0"x6'-8"	$16.95	$14.00	$ 7.40
2'-4"x6'-8"	18.65	15.40	8.50
2'-6"x6'-8"	19.30	15.80	8.50
2'-8"x6'-8"	19.95	16.55	9.35
3'-0"x6'-8"	21.75	18.25	10.00
2'-0"x7'-0"	—	15.15	9.55
2'-4"x7'-0"	19.95	16.55	10.65

Doors 1⅜" Thick Size	Plain Red Oak	Plain Birch	Phil. Mahog.
2'-6"x7'-0"	$20.70	$17.20	$10.65
2'-8"x7'-0"	21.40	18.15	11.55
3'-0"x7'-0"	23.10	19.60	12.20

"Economy" grade hollow core doors are marketed by some door manufacturers at about $3.00 per door less than the above prices. Before buying a door of this type, be sure it is going to stand up and not warp or twist.

Ready-Hung Interior Door Units

Ready-hung door units for interior use, available in a knocked-down package, include 1⅜" thick hollow core flush door, jambs, stops and complete hardware.

Ponderosa pine jambs are cut to length; side jambs are notched for head jamb; one side jamb has 2 half-hinges mortised and applied while the other is mortised to receive strike plate.

Ponderosa pine stops are cut to length, but not mitered.

Hollow core flush doors are prefit for proper clearance; edges are eased; the other 3 half-hinges are mortised and applied and door is bored and mortised for lock set.

Hardware includes 1 pair, 3½"x3½" brass butts, and polished brass tubular type lock set. For lock set with button-in-knob type locking device, add 75 cts. to prices given below.

Prices are for units with adjustable jambs, from 4⅜" to 5½" jambs.

Door Size	Western Pond Pine	Philippine Mahog. Doors	Birch Doors
1'-6"x6'-8"	$37.25	$30.70	$37.60
2'-0"x6'-8"	41.65	31.25	39.55
2'-4"x6'-8"	43.00	32.70	41.35
2'-6"x6'-8"	44.90	32.70	41.75
2'-8"x6'-8"	45.65	33.40	42.65

Interior Panelled Doors

Five cross panel doors have western pine stiles, rails and standard raised panels.

Regular two panel doors have western pine stiles and rails with 3-ply fir panels.

Size	Five Cross Panel	Two Regular Panel
2'-0"x6'-8"x1⅜"	$18.90	$17.75
2'-4"x6'-8"x1⅜"	21.00	19.65
2'-6"x6'-8"x1⅜"	21.85	20.50
2'-8"x6'-8"x1⅜"	22.85	21.45
3'-0"x6'-8"x1⅜"	24.80	23.20

Sliding Closet Doors

With the popularity of sliding doors for closets, many different combinations of doors, materials and sizes are on the market.

With some of them, the doors are the same height as the other doors in the room or building, i.e. 6'-8" or 7'-0", while in others the doors extend to the ceiling, so that when opened, they provide access to the storage shelves at the top.

While there are many different types of doors, hardware, etc., the ones described below are of the type usually found in moderate class housing and apartments.

Frames for sliding doors may be obtained in kits containing two side jambs, head assembly with track attached and necessary hardware for hanging doors. Available with 5⅜" jambs for lath and plaster construction, or with 4⅝" jambs for dry wall construction. Openings may be arranged for two, three, or four by-passing doors. Any 1⅜" thick doors can be used.

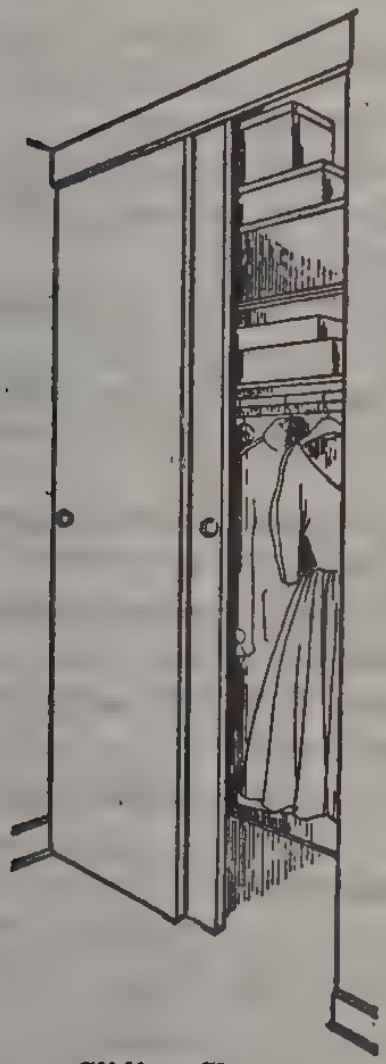
The following table lists by-passing units, no jambs or casing, hardware applied and pulls installed for a variety of 1⅜" thick doors.

Opng.	H. C. Luan	H. C. Birch	H. C. Oak	W. P. Louver	W. P. Half Louver	6 Pan. W. P. Col.
4'-0"x6'-8"	$22.00	$31.00	$33.00	$41.00	$43.00	$54.00
5'-0"x6'-8"	22.50	33.00	36.00	43.00	50.00	60.00
6'-0"x6'-8"	25.00	40.00	42.00	48.00	55.00	70.00

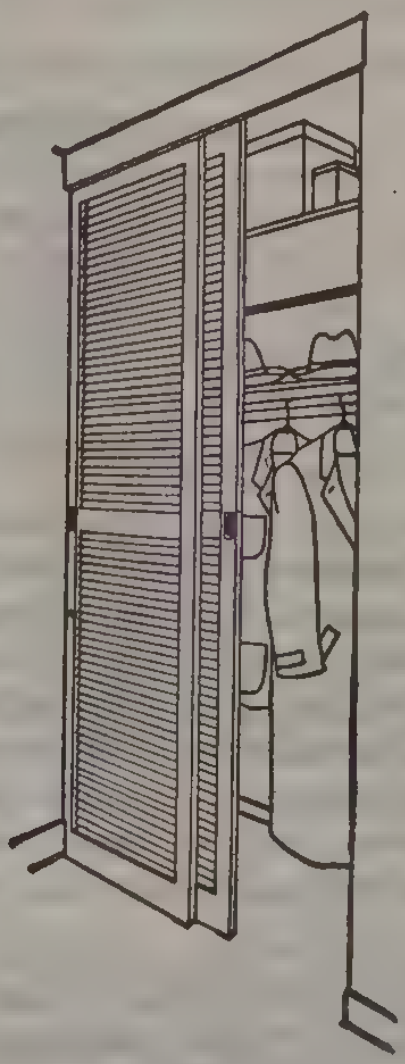
Bi-folding doors offer the advantage of full access to the closet behind. They are available in kits with doors, hinges, pivots, and guide assembly and track. Jambs, casing and knobs not included.

Openings to 3'-2" panels hinged one side. 4'-0" and over 4 panels hinged two sides.

Opng.	1⅜" H. C. Luan	1⅜" H. C. Birch	1⅛" Louver	1⅛" Half Louver	1⅜" 3 Pan. W. P. Col.
2'-0"x6'-8"	$13.00	$14.50	$17.00	$21.00	$32.00
2'-6"x6'-8"	13.50	16.00	18.00	22.00	38.00
3'-0"x6'-8"	14.00	17.00	19.00	23.00	42.00
4'-0"x6'-8"	22.00	27.00	31.00	38.00	60.00
5'-0"x6'-8"	24.00	31.00	36.00	41.00	72.00
6'-0"x6'-8"	26.00	33.00	38.00	45.00	85.00



Sliding Closet Doors



Louver Sliding Closet Doors

SPECIAL DOORS—VENEERED HARDWOOD

Rules for Estimating Prices of Special Veneered Doors

The following rules may be used for estimating the approximate cost of special doors consisting of a regular layout of stock

stiles, rails, and 3-ply $\frac{3}{16}$-inch panels. One-eighth inch veneers are used on doors up to 3 by 8 feet in any size where doors are not over 1¾ inches thick. Do not figure any door as containing less than 17½ square feet, as this is always considered the minimum size for figuring doors.

Kinds of Doors	Price Per Sq. Ft.
Class A.—Douglas fir, Ponderosa pine, unselected gum	$2.00
Class B.—Plain oak, Philippine mahogany, unselected birch, ash, chestnut, poplar or cypress	2.50
Class C.—Quartered oak, quartered sycamore, quartered figured gum, red cedar	3.00
Class D.—Mahogany, cherry, black walnut	3.00

Extras Applying to the Above Prices

After the price of an ordinary veneered door has been obtained as described above, the following amount should be added to such total price for extras as shown:

Thick Doors—For doors over 1¾ inches thick, for each ¼ inch or fraction in thickness, add $3.00

Two Kinds of Wood—For doors veneered with two kinds of wood, figure on basis of highest price wood and add per door 2.50

Wide Doors—For doors over 3 feet wide, and for each additional 6 inches or part thereof in width up to 4'-0" .. 3.00

High Doors—For doors over 8 feet high, for each additional 6 inches or part thereof in height, add 5.00

Wide Stiles—For doors with stiles over 5 inches wide, for each additional ¼ inch or part thereof, add 1.50

Extra Panels—For each additional panel over six (6) in number, add for each panel 3.50

Flush Molded Doors—Not over 1⅛ inches wide:

	One Side	Two Side
Class "A," Add per panel	$1.75	$3.00
Class "B," Add per panel	2.00	3.50
Class "C," Add per panel	2.25	4.00
Class "D," Add per panel	2.50	4.50

Raised Molded Doors—Not over ⅞x1¾ inches:

	One Side	Two Side
Class "A," Add per panel	$2.25	$4.00
Class "B," Add per panel	2.75	5.00
Class "C," Add per panel	3.00	5.50
Class "D," Add per panel	3.25	6.00

Four Cross Panel Doors: For doors containing 4 cross panels, add to price of door..... 5%

Three Cross Panels: For doors containing 3 cross panels, add to price of door..... 10%

Two Panel Doors: For doors containing either two cross or upright panels, add to price of door..... 15%

One Panel Doors: For doors containing one vertical panel, add to price of door..... 20%

Slab Doors: For solid slab doors, add to price of door... 25%

Doors Paneled Differently Each Side:
For doors paneled differently each side, add per door....$7.50

Banding Doors:
For banding doors not over 3′-6″x8′-0″, add per door.... 5.00
For banding doors over 3′-6″x8′-0″, add per door..... 6.50

Folding Door Astragal:
One kind of wood, stock pattern (loose), each..... 3.50

Sliding Door Astragal: One kind of wood, stock pattern (loose), for 1¾-inch doors, per pair..... 4.50

Sliding Door Astragal: One kind of wood, stock pattern (loose), for 2¼-inch doors, per pair..... 5.00

Astragals: Two kinds of wood, add to the above prices.. 50%

Rabbeting and Beading Folding Doors:
For rabbeting and beading folding doors, add per pair..$3.50

Hand Smoothing Doors: For hand smoothing doors not over 3′-0″x8′-0″, add per door..... 3.00
For hand smoothing doors over 3′-0″x8′-0″, add per door 5.00

Sash Doors: For sash doors having square or rectangular lights, add per light $1.00

Mirror Doors:
For mirror doors (without mirror), add..... 4.00

Thick Veneers: For doors having veneers over ⅛″ thick, add for each additional ⅛″ or fractional part thereof....20%

Five Ply Veneer: For doors wanted with panels of 5-ply veneers, add per door.....$5.00

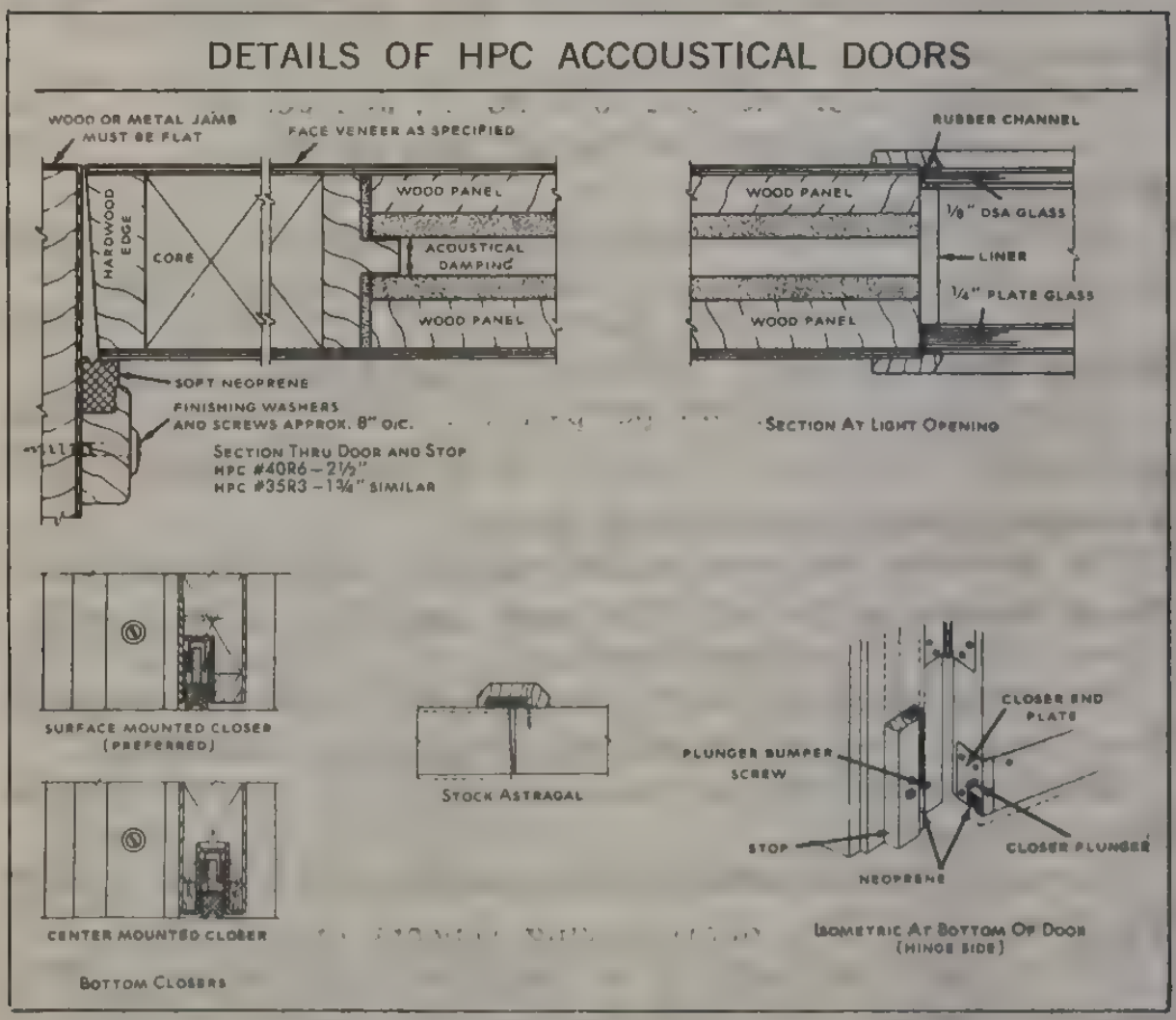
Inlaid Slab Doors: Where slab doors are wanted inlaid with strips of ebony and holly, add $7.00 for each side.

Quantity Extras: If less than 5 doors of the same design and size are ordered, add 10% to the above prices. If total order or estimate is less than 50 doors, add an additional 5%.

Hardwood Sound Insulating Doors*

Eggers Hardwood Products Corp.'s* acoustical doors are for use in consultation rooms, conference rooms, hospitals, clinics, music rooms, television and radio studios, and other areas where acoustical levels must be closely maintained.

Dependent on the desired decibel reduction, or acoustical efficiency, Hardwood doors are identified and furnished in three models as follows:



The HPC 35 models are 1¾" thick and are rated in sound transmission class 36. The HPC 40 models are 2½" thick and are rated in sound transmission class 41. A door 3" thick is also made which has superior accoustical qualities.

*Eggers Hardwood Products Corp., Neenah, Wisconsin.

Eggers Hardwood Products Corp.'s acoustical doors are made in a wide selection of face woods. Custom finishing of doors is available.

These are veneered doors and, as such, can be furnished with veneers to match those of the balance of the doors in the building. Any standard hardware may be used for door erection.

The following prices include bottom closers, stops, gaskets and stop adjusters and are for standard rotary cut veneers of natural birch and red oak.

Special sizes: For intermediate sizes add or deduct for each 2" or fraction thereof in:

	1¾"	2½"	3"
Width (Maximum 4'-0")	$4.40	$5.20	$5.70
Height (Maximum 8'-0")	4.10	4.30	4.75

Prices on sizes larger than 4'-0"x8'-0" may be had on request.

Size	Prices of Hardwood Sound Insulating Doors** 1¾" 35 Decibel	2½" 40 Decibel	3" 43 Decibel
2'-6"x6'-8"	$176.50	$189.00	$219.50
2'-8"x6'-8"	181.00	194.00	224.50
3'-0"x6'-8"	189.00	203.50	234.00
3'-4"x6'-8"	199.50	215.50	246.00
3'-6"x6'-8"	206.00	221.50	251.50
3'-8"x6'-8"	212.00	228.00	258.50
2'-6"x7'-0"	180.50	193.50	224.00
2'-8"x7'-0"	184.50	198.00	228.50
3'-0"x7'-0"	193.00	207.50	238.00
3'-4"x7'-0"	203.50	219.50	250.00
3'-6"x7'-0"	209.00	225.50	256.00
3'-8"x7'-0"	215.00	232.50	262.50

**f.o.b. factory, uncrated.

Light openings:	1¾"	2½"	3"
Rectangular vision light not over 18" square	$26.00	$26.00	$26.00

Astragals.—Astragals for pairs of doors, 2½"x1" in any wood to match face veneer with 1"x½" rubber gasket, $13.30 per pair.

For rounding meeting edges and grooving one edge with Eveleth bumper strip, add $15.00.

Other woods.—For other woods add to the total price the following percentages:

Sliced natural birch and sliced red oak 3%
Rotary cut red or white birch and rotary cut plain white oak . 7%
Sliced red or white birch and sliced plain white oak 20%
Rift sliced white oak and sliced African mahogany 11%
Sliced American black walnut 15%

GARAGE DOORS

Overhead Garage Doors.—Overhead garage doors are furnished in several different styles, including the one-piece overhead door; self-balancing overhead door and the spring balanced over-head doors.

For an average opening up to 8'-0"x8'-0", a carpenter should place tracks, fit and hang doors and apply the necessary hardware in 3 to 4 hours, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	4	$.....	$.....	$6.75	$27.00

Where the doors are installed by experienced men who make a specialty of installing overhead garage doors, allow 3 to 4 hours time per opening up to 9'-0"x7'-0".

For larger openings up to 16'-0" wide and 7'-0" high, where one wide overhead folding door is used, a carpenter should place tracks, fit and hang doors and apply the necessary hardware complete in 4 to 6 hours, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	6	$.....	$.....	$6.75	$40.50

Where the doors are installed by experienced men who make a specialty of installing overhead garage doors, allow 4 to 6 hours time per opening up to 16'-0"x7'-0".

GARAGE, FACTORY AND WAREHOUSE DOORS

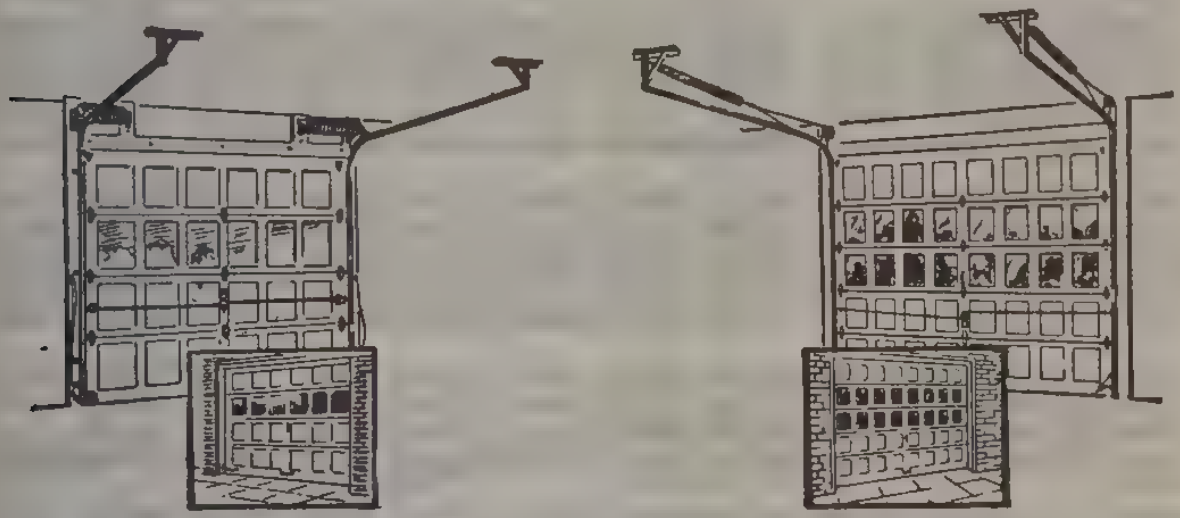
Made of western ponderosa pine, with flat panels or prepared for glass as desired. No door figured as containing less than 21 sq. ft.

Sq. Ft. per Door	Per Sq. Ft. 1¾" Thick	Per Sq. Ft. 2¼" Thick	Per Sq. Ft. 2¾" Thick	Per Sq. Ft. 3" Thick
Minimum 21 sq. ft.....	$2.70	$2.90	$3.30	$3.10
Door 24 sq. ft.....	2.40	2.50	3.00	3.40
Door 26 to 32 sq. ft.....	2.15	2.35	2.90	3.25
Door 32 to 36 sq. ft.....	2.00	2.15	2.70	2.90
Door 36 to 40 sq. ft.....	1.45	1.60	2.15	2.70
Doors over 40 sq ft.....	1.25	1.45	2.15	2.70

For doors with raised panels, add $1.25 per panel.

Overhead Type Garage Doors

Overhead type garage doors counter-balanced and controlled in any position by oil tempered torsion springs. Cables are secured at the bottom of the door on each side and are directly



Overhead Type Garage Doors

connected with the pair of balancing springs located immediately over the door.

Ball bearing rollers carry all sections of door over a continuous channel track. The track has a flange on it which keeps the rollers in the track.

Continuous angle track mountings are provided for all vertical tracks, which fasten solid against the jamb.

Doors have clear, kiln dried fir or spruce sections, with hardboard fir panels. All joints are mortised, tenoned or doweled with steel pins and glued. All sections are rabbeted together to form air-tight joints when closed, fitted to net size, squared for opening and drilled for hardware. Sixteen inches of headroom is required.

Prices are for door complete with all necessary hardware, ready to install.

Doors over 12′-0″ wide have steel struts in intermediate sections to prevent sagging. Doors over 15′-0″ wide have steel struts in all sections.

Approx. Prices of Built-To-Order Sectional Overhead Type Doors

Widths Up To	Heights Up To										
	6′-6″	7′-0″	7′-6″	8′-0″	8′-6″	9′-0″	10′-0″	11′-0″	12′-0″	13′-0″	14′-0″
8′-0″	$85.00	$85 00	$91.00	$97.00	$102.00	$108.00	$121.00	$138.00	$150 00	$167.00	$180 00
8′-6″	88.00	90.00	97.00	102.00	108.00	115.00	132 00	146.00	163.00	178 00	190 00
9′-0″	92 00	96.00	102 00	109.00	115.00	126.00	140.00	154.00	173.00	188.00	206.00
9′-6″	97.00	101.00	108.00	114.00	125.00	133 00	148.00	168.00	182 00	204.00	220 00
10′-0″	102.00	106.00	113.00	120.00	131.00	140.00	160.00	176.00	192.00	215.00	230.00
10′-6″	106 00	111.00	119.00	130.00	139.00	147.00	168.00	184.00	206.00	225.00	250.00
11′-0″	111.00	117.00	129.00	137.00	146.00	153.00	175.00	190.00	217.00	241.00	268.00
11′-6″	118.00	122.00	134.00	142.00	152.00	166.00	183.00	208.00	226.00	252.00	286.00
12′-0″	124 00	130 00	140 00	149.00	163 00	172.00	193.00	217.00	245.00	272 00	300.00
12′-6″	130 00	136.00	146.00	156.00	169.00	180.00	205.00	226.00	254.00	295 00	318.00
13′-0″	137.00	141.00	151.00	167.00	177.00	187.00	215.00	241.00	271.00	308.00	340 00
13′-6″	141 00	146.00	162 00	173.00	183 00	200 00	222.00	251.00	288 00	326.00	354.00
14′-0″	146.00	152.00	169 00	179.00	190.00	207.00	230.00	268.00	300 00	340.00	374.00
15′-0″	160.00	169.00	180.00	193.00	208.00	222.00	254.00	295.00	330.00	372.00	400.00
16′-0″	172.00	179.00	192.00	210 00	224.00	245.00	277.00	322 00	360 00	396.00	437.00
17′-0″	184.00	190 00	210.00	224.00	245.00	265 00	304.00	342.00	384.00	430.00	494 00
18′-0″	197.00	206.00	224 00	245.00	265.00	288 00	330 00	370.00	416 00	484.00	535.00
19′-0″	228 00	237.00	260 00	281 00	308 00	323 00	368 00	412 00	490 00	538.00	580 00
20′-0″	247.00	258.00	280 00	308 00	334 00	360 00	407.00	445.00	500 00	562.00	628.00

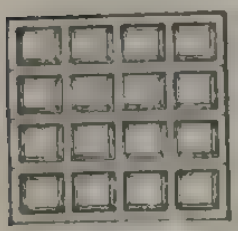
Extras for Overhead Garage Doors

Metal covering on doors. One side only, per sq. ft. $1.00. Two sides, per sq. ft. $1.60.

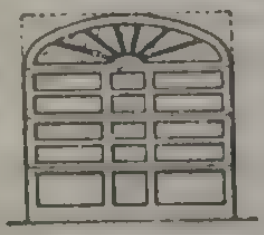
For doors 2¼″ thick, add to price of 1¾″ door price, per sq. ft. $0.80.

Always figure square footage on 6″ breaks, viz., 8′-3″x9′-2″ figured as 8′-6″x9′-6″.

Doors of special designs



Colonial



Fan Top

Vertical Battens

Diagonal Battens

Colonial doors, heavily molded outside with raised panels, add per sq. ft. $0.80.

For fan top on door, add $60.00 extra.

Vertical battens, 2-ply V-jointed or beaded, add per sq. ft. $1.00

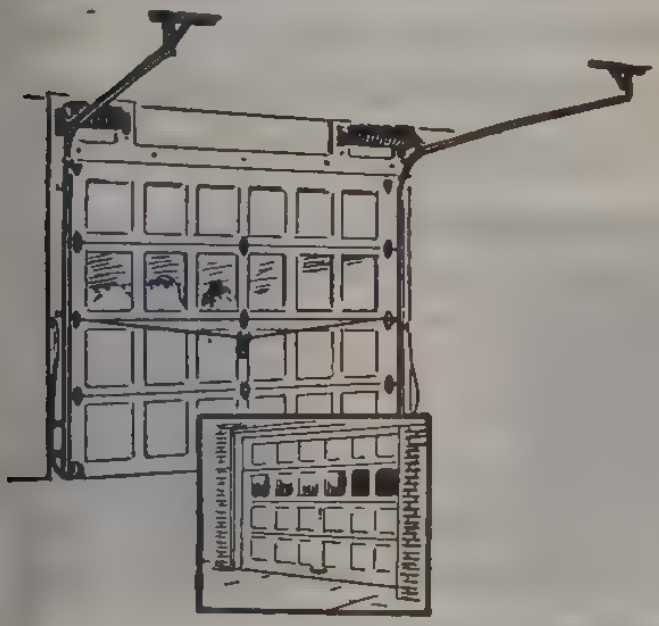
Diagonal battens, 2-ply V-jointed or beaded, add per sq. ft. $1.20

Special Hardware—Add per Door

Low headroom, 6″ minimum, for doors not over 132 sq. ft..$15.00
Low headroom, 6″ minimum, for doors not over 133 to 175 sq. ft. $26.00
Low headroom, 6″ minimum, for doors over 16′-0″ wide or over 12′-0″ high $38.00
High lift (for lubritoriums) up to 2′-0″ above head jamb...$22.00
High lift (for lubritoriums) up to 5′-0″ above head jamb...$45.00

Standard Size, Sectional Overhead Type, Garage Doors

Furnished complete with hardware, including cylinder lock, springs and track for 16″ or more headroom. Doors may be furnished with all wood panels or top section open for glass. Glass not included. Approximate prices:



Size Opening	1⅜″ Thick	1¾″ Thick
8′-0″x 6′-6″	$ 65.00	$ 73.00
8′-0″x 7′-0″	67.00	75.00
8′-0″x 7′-6″	70.00	81.00
8′-0″x 8′-0″	73.00	85.00
9′-0″x 7′-0″	72.00	84.00
14′-0″x 7′-0″	135.00	148.00
15′-0″x 7′-0″	143.00	154.00
16′-0″x 7′-0″	152.00	162.00
10′-0″x10′-0″	....	140.00
12′-0″x10′-0″	....	172.00
10′-0″x12′-0″	....	185.00
12′-0″x12′-0″	....	230.00

Electric Door Operators

Operators may be used with any type of overhead doors. Motors are suitable for single phase, 60 cycle, 110-120 Volt AC power supply, and are of the reversing type which permit stopping and changing direction at any point of the door travel. Adjustable limit switches stop the door automatically at top and bottom of door openings.

Safety mechanism automatically reverses the door if it meets an obstruction while in operation, or the door will stop and the operator will shut off.

Doors are driven by means of a roller chain fastened to a shoe sliding on 2 steel tracks. The shoe is connected to the door by a detachable arm.

Single door residential operator with ¼-Hp. motor for door up to 22 ft. wide, 7 ft. high, complete with one toggle type control station..... $100.00

For commercial door operator, with ¼-Hp. motor for door not over 140 sq. ft. nor over 10 ft. high..... 155.00

Commercial door operator, with ⅓-Hp. motor for door not over 168 sq. ft. or 12 ft. high..... 170.00

Commercial door operator, with ½-Hp. motor for door not over 224 sq. ft. or 14 ft. high..... 180.00

Extra toggle type control station for commercial operator 5.00

Extra key switch (for residential operator only)..... 11.00

An experienced mechanic should install an electric door operator in 1 to 2 hours after the necessary wiring is in place

Electronic Door Operators

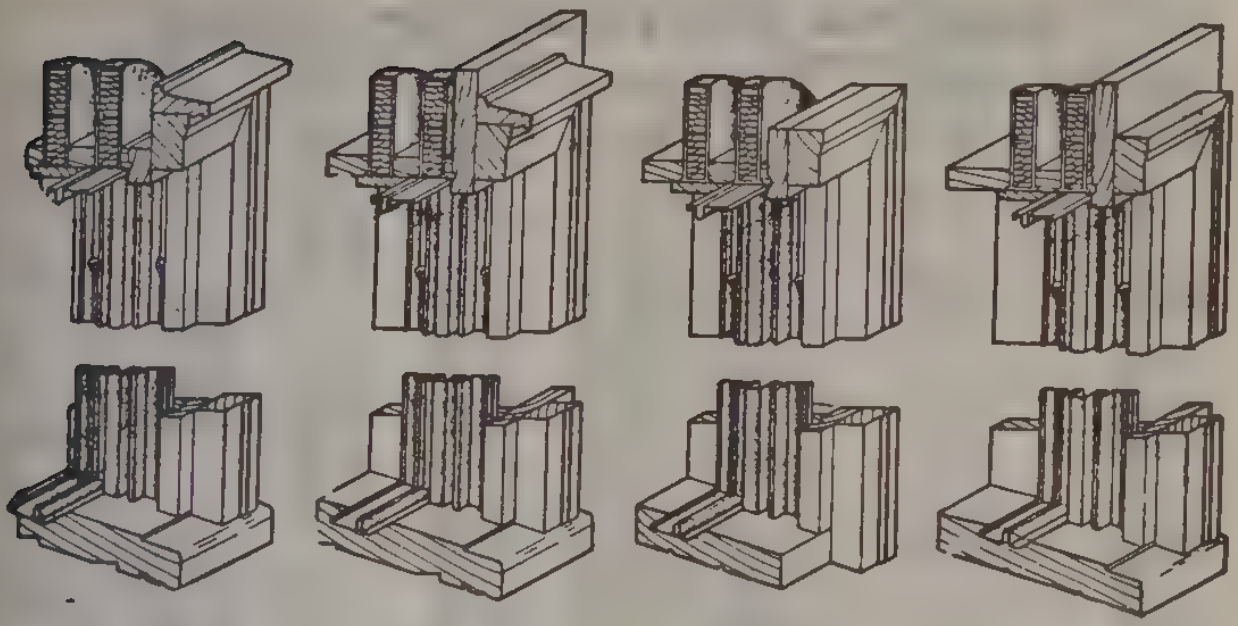
For use where a button is placed on the dash of each automobile using the garage. A push of the button operates the doors from the car.

For residential doors up to 16'-0"x8'-0", approx. price installed $235.00

An experienced mechanic should install an electric door operator in 1 to 2 hours after the necessary wiring is in place

WINDOW FRAMES

Wood windows today are most generally sold as complete units with frame, sash, operating hardware, weatherstripping and glazing assembled at the factory. Frames are treated. The following sizes are based on units manufactured in the Chicago area by ROW Window Company. Sizes for other manufacturers such as Anderson, Pella, or Caradco, will vary slightly. Prices as given should, of course, be checked locally and will vary considerably geographically and as to the size of order and even as to delivery to local dealer or to job site. The prices quoted will be helpful, however, for comparing the various window and glazing types



5¼" Stud Wall — 9" or 13" — 10"
No Wind Break — With Wind Break — Brick Wall — Brick Ven. Wall

Stock Western Pine Windows

One Pane

Two Pane

Six Pane

Double Hung Units Preglazed SS*

Glass Size	Stud Opening Width	Stud Opening Height	Number of Panes Per Sash One	Two	Four	Six	Eight
16x16	1'-11"	3'- 6"	$25.80	$27.30	$28.05	$	$
20		4'- 2"	25.41	30.00	30.75		
24		4'-10"	31.86	33.51	34.29		
28		5'- 6"	34.53	36.36	36.75		
32		6'- 2"	39.03	41.01			
36		6'-10"	42.21	44.91			
20x16	2'-3"	3'- 6"	27.84	29.82	30.06	31.74	
20		4'- 2"	30.78	32.88	32.85	34.56	

*For double hung units in pairs, triple or quadruple arrangements, multiply costs by two, three and four respectively.

Double Hung Units Preglazed SS*—Continued

Glass Size	Stud Opening Width	Stud Opening Height	Number of Panes Per Sash One	Two	Four	Six	Eight
20x24	2'-3"	4'-10"	$34.38	$36.66	$36.54	$38.31	$
28		5'- 6"	36.84	39.21	39.21	40.98	
32		6'- 2"	41.91	44.10	44.46		
36		6'-10"	45.00	47.82	47.61		
24x16	2'-7"	3'- 6"	29.19	31.26		32.73	
20		4'- 2"	32.19	34.47		35.46	
24		4'-10"	36.03	38.28	38.16	39.48	
28		5'- 6"	38.73	40.92	41.43	41.88	
32		6'- 2"	43.92	46.41	46.20		
36		6'-10"	47.25	50.19	49.68		
28x16	2'-11"	3'- 6"	30.81	32.91		34.35	
20		4'- 2"	33.66	35.85		37.47	
24		4'-10"	37.77	39.96		41.67	
28		5'- 6"	40.83	43.14		44.58	
32		6'- 2"	46.44	48.90		50.67	
36		6'-10"	49.98	53.10		54.24	
32x16	3'-3"	3'- 6"	33.09	35.73		36.90	38.85
20		4'- 2"	36.48	39.09		40.26	41.01
24		4'-10"	40.74	43.62		44.04	45.12
28		5'- 6"	44.22	47.22		47.07	48.15
32		6'- 2"	49.14	52.26		53.19	
36		6'-10"	53.04	56.52		57.00	
36x16	3'-7"	3'- 6"	34.86	37.56		45.27	40.08
20		4'- 2"	38.19	41.01		48.99	43.26
24		4'-10"	42.69	45.63		54.30	47.04
28		5'- 6"	46.35	49.47		58.11	50.19
32		6'- 2"	51.69	55.17			55.38
36		6'-10"	55.65	59.52			
40x16	3'-11"	3'- 6"	37.29	40.14			
20		4'- 2"	40.14	43.05			44.82
24		4'-10"	44.79	48.06			49.32
28		5'- 6"	49.02	52.53			52.59
32		6'- 2"	54.54	57.96			58.71
36		6'-10"	59.07	62.37			63.72

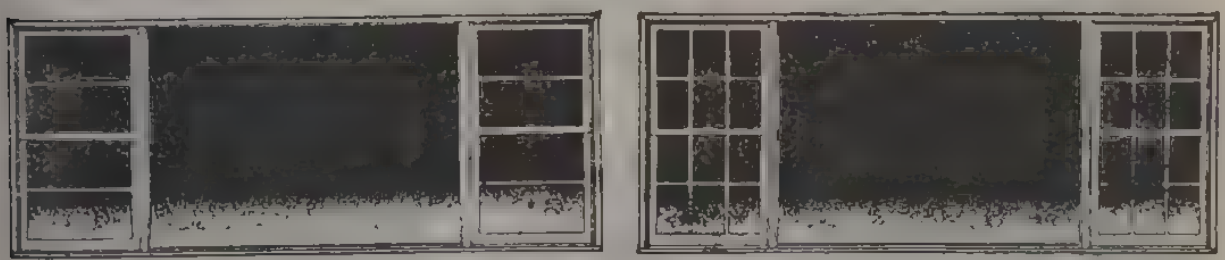
*For double hung units in pairs, triple or quadruple arrangements, multiply costs by two, three and four respectively.

Double Hung Sash Glazed With ½" Insulating Glass

Glass Size	Stud Opening Width	Stud Opening Height	Cost	Add for Rem. Grilles Diamond	Colonial
16x20	1'-11"	4'- 2"	$46.29	$	$
24		4'-10"	51.00		
28		5'- 6"	55.80		

Double Hung Sash Glazed With ½" Insulating Glass—Continued

Glass Size	Stud Opening Width	Stud Opening Height	Cost	Add for Rem. Grilles Diamond	Add for Rem. Grilles Colonial
20x16	2'-3"	3'- 6"	$45.54	$13.86	$2.67
20		4'- 2"	50.37	14.31	3.09
24		4'-10"	55.59	14.97	3.57
28		5'- 6"	60.27	15.42	4.02
24x16	2'-7"	3'- 6"	48.87	14.31	3.48
20		4'- 2"	54.18	14.97	3.78
24		4'-10"	59.31	15.75	4.11
28		5'- 6"	64.83	16.11	4.44
28x16	2'-11"	3'- 6"	52.59	15.54	3.87
20		4'- 2"	57.81	16.38	4.20
24		4'-10"	63.27	17.10	4.53
28		5'- 6"	68.49	17.85	4.86
32x16	3'-3"	3'- 6"	56.73	15.93	4.32
20		4'- 2"	62.25	16.95	4.65
24		4'-10"	67.98	17.55	4.98
28		5'- 6"	73.23	17.97	5.31
36x16	3'-7"	3'- 6"	60.69	16.79	4.74
20		4'- 2"	66.39	17.55	5.01
24		4'-10"	72.06	18.36	5.28
28		5'- 6"	81.09	18.63	5.61
40x16	3'-11"	3'- 6"	64.65	17.10	5.13
20		4'- 2"	70.47	17.55	5.40
24		4'-10"	79.74	18.36	5.67
28		5'- 6"	85.71	19.14	5.94
24x24/36	2'- 7"	5'-10"	67.68	18.66	5.37
28x24/36	2'-11"	5'-10"	73.68	19.35	5.97
32x24/36	3'- 3"	5'-10"	77.34	20.04	6.63
36x24/36	3'- 7"	5'-10"	83.22	20.43	7.89
40x24/36	3'-11"	5'-10"	90.24	20.91	8.70



Panorama Window Units

Fixed Center Sash for Use with Double Hung Units

Glass Size	Stud Opening Width *	Stud Opening Height	Glazed Insulating 1"	Glazed Insulating 11/16"	Glazed Flat Sht.
36x34		3'-6"	$	$ 59.40	$37.11
44					42.81

*Width depends on size of side sash selected.

Fixed Center Sash for Use with Double Hung Units—Continued

Glass Size	Stud Opening Width *	Height	Glazed Insulating 1"	11/16"	Glazed Flat Sht.
48x34		3'- 6"	$	$ 73.74	$47.04
56				84.51	50.70
36x42		4'- 2"		66.36	42.96
44					48.78
48			112.29	81.81	53.28
56			126.87	89.04	57.69
36x46		4'- 6"		71.19	50.34
48			122.37	86.46	57.66
56			138.21	97.74	62.46
64			150.87		
72			168.60		
36x50		4'-10"		74.97	50.58
48			129.42	91.83	59.73
56			142.83	102.03	64.74
60					70.68
64			159.42		76.62
72x50		4'-10"	185.13		
80			199.29		
96			230.43		
48x58		5'- 6"	143.58		65.73
56			161.73		71.43
64			184.02		
72x58		5'- 6"	204.93		
80			220.71		
96			255.06		
48x62		5'-10"			69.09
56x66		6'- 2"	182.19		
64			202.80		
72			225.36		

*Width depends on size of side sash selected.

Lineal Casing.—Casing is available in 14'-6" and 7'-3" lengths at $3.33 and $1.77 respectively.

Gliding Window Units

Gliding window units may be used in any room of the house but are more frequently used in enclosed porches, as high windows in bedrooms, baths and other similar areas where interior wall space is a consideration.

By using the high narrow windows, furniture may be placed under them making much better interior arrangements possible.

The gliding windows described below are furnished complete with frames, sash, weatherstrips, so that each sash slides to the

Gliding Window Units

opposite side of the opening for ventilation, but when fully closed is weatherstripped on all four sides.

Prices for complete gliding window units, assembled and carton packed:

Gliding Window Units

Glass Size	Stud Opening Width	Height	Cost per unit glazed ss	Add for alum. storm sash
16x16	3'- 3¼"	1'-11½"	$28.29	$24.36
20		2'- 3½"	29.73	"
24		2'- 7½"	31.02	"
28		2'-11½"	32.76	"
32		3'- 3½"	34.47	"
36		3'- 7½"	36.00	"
40		3'-11½"	38.61	"
20x16	3'-11¼"	1'-11½"	31.02	"
20		2'- 3½"	32.73	"
24		2'- 7½"	34.20	"
28		2'-11½"	35.73	"
32		3'- 3½"	37.92	"
36		3'- 7½"	39.42	"
40		3'-11½"	41.25	"
24x16	4'- 7¼"	1'-11½"	33.69	"
20		2'- 3½"	35.46	"
24		2'- 7½"	37.14	"
28		2'-11½"	38.88	"
32		3'- 3½"	41.10	"
36		3'- 7½"	42.90	"

Gliding Window Units—Continued

Glass Size	Stud Opening Width	Stud Opening Height	Cost per unit glazed ss	Add for alum. storm sash
24x40	4'- 7¼"	3'-11½"	$44.85	$24.36
28x16	5'- 3¼"	1'-11½"	37.05	"
20		2'- 3½"	38.70	"
24		2'- 7½"	40.62	"
28		2'-11½"	42.72	"
32		3'- 3½"	45.42	"
36		3'- 7½"	47.28	"
40		3'-11½"	49.80	25.32
32x16	5'-11¼"	1'-11½"	41.10	24.36
20		2'- 3½"	43.23	"
24		2'- 7½"	45.21	"
28		2'-11½"	47.73	"
32		3'- 3½"	49.74	25.32
36		3'- 7½"	51.96	26.28
40		3'-11½"	54.63	27.24

Screens and operating hardware are included in the above prices.

Gliding type window units may be ordered with a fixed glass in the center and two gliding sash on either end which, when open pass in front of the fixed panel.

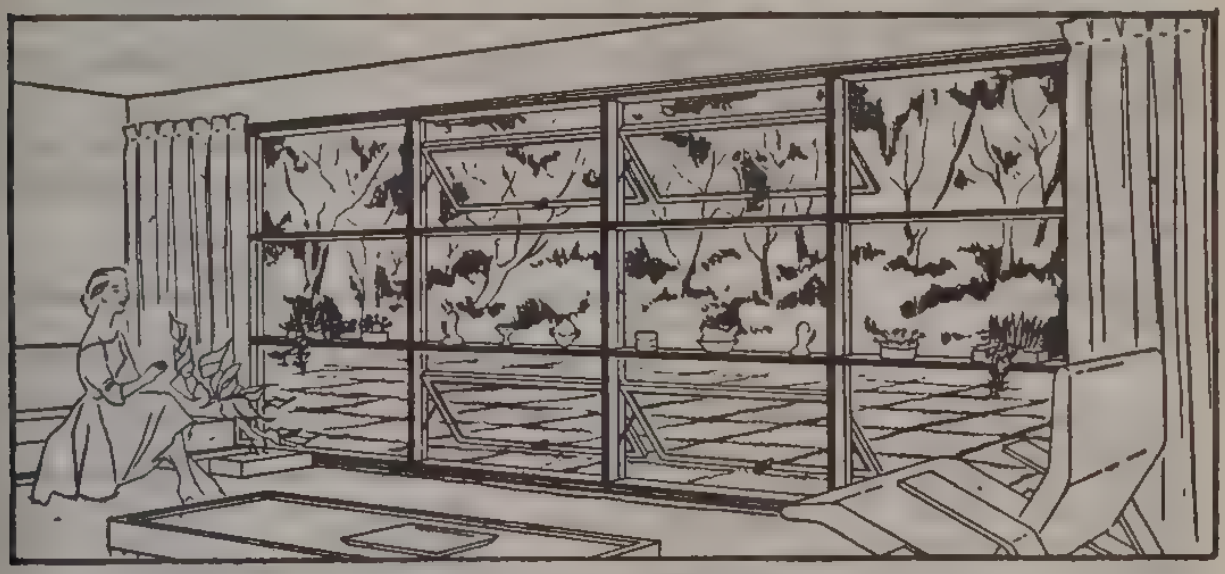
Frame Extras

Liners for 4⅞" or 5¼" jamb	$ 0.60
Liners for 5" or 5⅛" jamb	1.20
Mullion centers, wider than standard (1½"), for each 1", add	1.80
Sill horn only, up to 12", one side only, add	1.35
Sill horn only, up to 12", both sides, add	2.70
Sill horn and 10" S4S casing, one side only, add	6.30
Sill horn and 10" S4S casing, both sides, add	12.60
Sill horn and 10" S4S casing, over 10", per inch, add	2.25
Combination of door and window frame, add	7.50

Sash Extras

Glazing with obscure glass, add to SS list, per square foot	$ 0.75
Rectangular or square divided lights, per light, add	.90

Triple units (3 pairs of gliding sash) are 3 times the price of a single unit, plus $2.10.



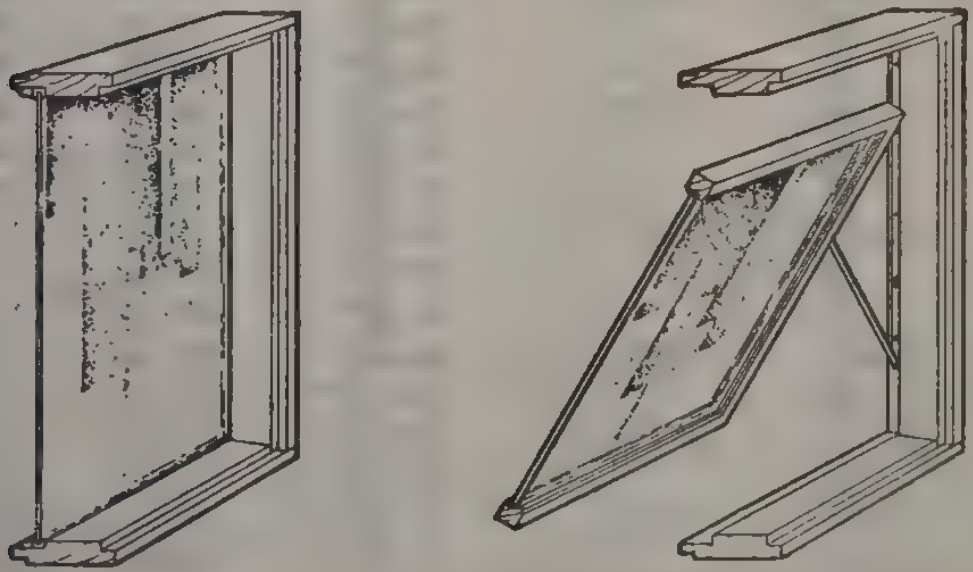
Glass Wall Panel Units

Awning Wall Panel Units

Awning units are a system of window panel arrangement ranging from a single individual panel to a multiple 12 panel unit, as illustrated, which is used as a picture frame unit.

Awning units are designed to give a selection of either stationary glass panels, ventilating sash panels or a combination of both. Both come glazed with ½" insulated glass, ¼" plate or DS glass, bedded in mastic.

Ventilating units have 1¾" sash, hinged at the top which can be opened about 35 degrees, closed or held in intermediate posi-



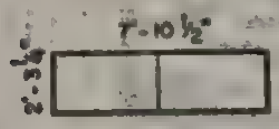
Glass Panel Wall Units

Stationary Ventilating

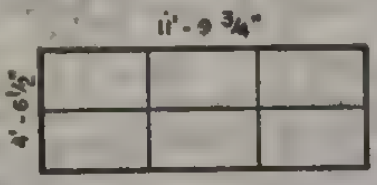
tion by rotary operators. Operators have worm gears, twin arms of cadmium plated steel, removable brass plated handles and are self-locking.

Screens for all ventilating units have aluminum frames and 14 x 18 mesh aluminum screen wire.

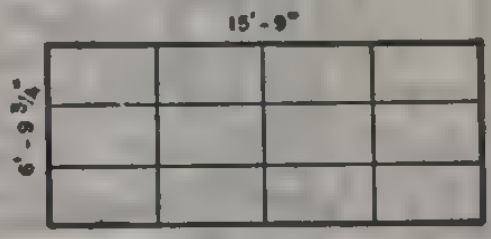
Glass wall panel units come completely set up, glazed and carton packed. The ventilating units are weatherstripped, operators are applied and screens installed in frames.



2 wide and 1 high can be used in bedrooms, providing extra wall space for furniture placement.



3 wide and 2 high are effectively used in dining rooms or dining alcoves.



Awning units room width, ceiling height, add charm to living rooms and solariums.

Awning Window Units

Glass	Size	Stud Opening Width	Stud Opening Height	Cost per Unit Glazed SSB*	Cost per Unit Glazed ½" in.**
1 High	27x14	2'-9⅞"	2'-0½"	$45.12	$48.87
	18		2'-4½"	48.87	53.19
	22		3'-0½"	51.24	56.07
	36x14	3'-7¼"	2'-0½"	52.29	57.18
	18		2'-4½"	55.11	60.45
	22		3'-0½"	57.90	63.75
	44x14	4'-3¼"	2'-0½"	56.88	62.88
	18		2'-4½"	60.06	66.48
	22		3'-0½"	62.76	69.81
2 High	27x14	2'-9⅞"	3'-1⅜"	77.16	85.38
	18		3'-9⅜"	83.52	93.00
	22		4'-5⅜"	89.34	99.73
	36x14	3'-7¼"	3'-1⅜"	86.01	96.72
	18		3'-9⅜"	93.30	104.97
	22		4'-5⅜"	99.81	112.59
	44x14	4'-3¼"	3'-1⅜"	92.91	105.96
	18		3'-9⅜"	100.89	114.93
	22		4'-5⅜"	107.28	122.67
3 High	27x14	2'-9⅞"	4'-6 3/16"	103.50	115.83
	18		5'-6 3/16"	113.67	127.86
	36x14	3'-7¼"	4'-6 3/16"	114.60	130.68
	18		5'-6 3/16"	126.15	143.67
	44x14	4'-3¼"	4'-6 3/16"	123.51	143.10
	18		5'-6 3/16"	136.08	157.14

*Storms and screens included
**Screens included

PICTURE WINDOW UNITS WITH AWNING SIDES

2-High Sides—14¼" Vents—Height Opening—Stud 3'-2⅛"

Sides	Center	Stud Opening	Sides—½" Insul. Ctr. 1" Insul.	Sides—½" Insul. Ctr. 11/16" Insul.	Sides—SSB Ctr. Sheet
27¼	36⅝x30¼*	8'-11⅞"	$214.02	-	$192.09
36⅝	" *	10'- 6⅝"	236.70	-	209.79
44⅝	" *	11'-10⅝"	255.18	-	223.59
27¼	44⅝x30¼*	9'- 7⅞"	219.87	-	197.91
36⅝	" *	11'- 2⅝"	242.55	-	215.61
44⅝	" *	12'- 6⅝"	261.03	-	229.41

*Made 1¾" sash — ½" insulating

2-High Sides—22¼" Vents—Height Opening—Stud 4'-6⅛"

27¼	48½x46	9'-11⅞"	$322.23	$286.32	$236.34
36⅝	"	11'- 6⅝"	347.55	311.64	257.28
44⅝	"	12'-10⅝"	367.71	331.80	272.22
27¼	56½x46⅛	10'- 7⅞"	338.07	297.60	241.14
36⅝	"	12'- 2⅝"	363.39	322.92	262.08
44⅝	"	13'- 6⅝"	383.55	343.08	277.02
27¼	64½x46	11'- 3⅞"	350.73	-	-
36⅝	"	12'-10⅝"	376.05	-	-
44⅝	"	14'- 2⅝"	396.21	-	-
27¼	72½x46	11'-11⅞"	368.46	-	-
36⅝	"	13'- 6⅝"	393.78	-	-
44⅝	"	14'-10⅝"	413.94	-	-

3-High Sides—14¼" Vents—Height Opening—Stud 4'-6 15/16"

27¼	35½x48⅛	8'-10⅞"	$332.19	$304.71	$258.33
36⅝	"	10'- 5⅝"	361.89	334.41	280.53
44⅝	"	11'- 9⅝"	386.73	359.25	298.35
27¼	44½x48⅛	9'- 7⅞"	352.17	313.74	262.89
36⅝	"	11'- 2⅝"	381.87	343.44	285.09
44⅝	"	12'- 6⅝"	406.71	368.28	302.91
27¼	55¼x48⅛	10'- 6⅞"	371.61	331.41	272.91
36⅝	"	12'- 1⅝"	401.31	361.11	295.11
44⅝	"	13'- 5⅝"	426.15	385.95	312.93
27¼	68¾x48⅛	11'- 7⅞"	397.77	-	-
36⅝	"	13'- 2⅝"	427.47	-	-
44⅝	"	14'- 6⅝"	452.31	-	-
27¼	75 x48⅛	12'- 2⅞"	420.12	-	-
36⅝	"	13'- 9⅝"	449.82	-	-
44⅝	"	15'- 1⅝"	474.66	-	-
27¼	93 x48⅛	13'- 8⅞"	451.50	-	-
36⅝	"	15'- 3⅝"	481.20	-	-
44⅝	"	16'- 7⅝"	506.04	-	-

3-High Sides—18¼" Vents—Height Opening—Stud 5'-6 15/16"

Sides	Center	Stud Opening	Sides—½" Insul. Ctr. 1" Insul.	Sides—½" Insul. Ctr. 11/16" Insul.	Sides—SSB Ctr. Sheet
27¼	35½x60⅜	8'-10⅞"	$376.11	-	$292.50
36⅝	"	10'- 5⅝"	407.73	-	317.46
44⅝	"	11'- 9⅝"	434.67	-	337.32
27¼	44½x60⅜	9'- 7⅞"	396.51	-	294.87
36⅝	"	11'- 2⅝"	428.13	-	319.83
44⅝	"	12'- 6⅝"	455.07	-	339.69
27¼	55¼x60⅜	10'- 6⅞"	418.77	-	303.81
36⅝	"	12'- 1⅝"	450.39	-	328.77
44⅝	"	13'- 5⅝"	477.33	-	348.63
27¼	68¾x60⅜	11'- 7⅞"	457.32	-	-
36⅝	"	13'- 2⅝"	488.94	-	-
44⅝	"	14'- 6⅝"	515.88	-	-
27¼	75 x60⅜	12'- 2⅞"	475.38	-	-
36⅝	"	13'- 9⅝"	507.00	-	-
44⅝	"	15'- 1⅝"	533.94	-	-
27¼	93 x60⅜	13'- 8⅞"	512.28	-	-
36⅝	"	15'- 3⅝"	543.90	-	-
44⅝	"	16'- 7⅝"	570.84	-	-

For masonry openings add 2¼" to width, 1⅛" to height

Combination unit with fixed sash above, awning unit below.

Vista-Vent Units

Vista-vents combine a bottom panel of an awning window unit with a fixed panel above. In the following table the first glass size is the upper fixed light; the second, the vent height below. Prices include storms and screens for SSB glazed, screens for ½" insulating glass.

Glass Size	Stud Opng.	Cost SSB	Cost ½" Insul.
27"x49" over 14"	2'-9⅞"x5'-11¾"	$89.85	$106.38
14 over 18	x3'- 4¾"	70.23	80.31
30 over 18	x4'- 8¾"	77.55	89.70
49 over 18	x6'- 3¾"	93.00	110.10
36 x49 over 14	3'-7¼"x5'-11¾"	101.37	124.53
	x3'- 4¾"	80.22	92.97
	x4'- 8¾"	88.59	103.11
	x6'- 3¾"	104.94	128.55
44 x49 over 14	4'-3¼"x5'-11¾"	114.99	138.96
14 over 18	x3'- 4¾"	89.16	104.16
30 over 18	x4'- 8¾"	99.81	115.47
49 over 18	x6'- 3¾"	118.95	143.16

Casement Units

Glass Size	Stud Opening Width	Stud Opening Height	Cost Glazed SSB	Cost Glazed ½" insulating
16x24	1'-9⅞"	2'-6 9/16"	$45.66	$49.71
30		3'-0 ¾"	48.90	53.82
36		3'-6 ¾"	52.02	57.78
49		4'-6 15/16"	60.15	67.02
61		5'-7 ⅛"	67.20	76.71
21x24	2'-2⅜"	2'-6 9/16"	47.88	53.16
30		3'-0 ¾"	52.11	57.36
36		3'-6 ¾"	55.68	61.50
49		4'-6 15/16"	63.72	71.79
61		5'-7 ⅛"	71.46	81.57
25x36	2'-6⅞"	3'-6 ¾"		65.22
49		4'-6 15/16"		75.96
61		5'-7 ⅛"		87.24

The above prices include screens and storm sash for SSB units. Casement sash may be ordered in gangs of two, three, four or five. Prices for each additional unit in a gang arrangement decline approximately 10%. It is thus cheaper to use casements in groups than as individual units. Additional savings will also be realized in gang arrangements in fewer jambs to form and caulk providing the lintel construction does not become more costly due to the longer span. If some of the sash are ordered as stationary units a further savings of $15.00 on the basic price per opening can be made.

If storm sash are eliminated, deduct:

16x24	$3.81	21x24	$4.05
30	4.05	30	4.54
36	4.47	36	4.92
49	5.36	49	6.00
61	6.57	61	8.51

Sash may be ordered with removable grilles of either diamond or rectangular (Colonial) design or with the addition of horizontal bars. Costs are as follows:

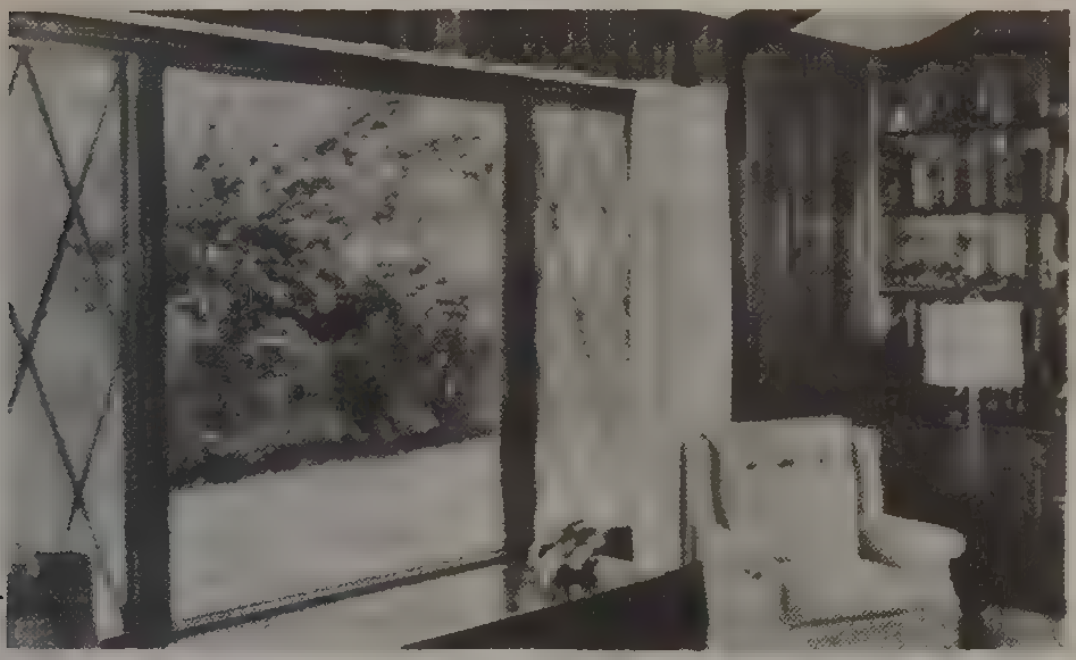
Diamond				Rectangular	
16x24	$8.58	21x24	$9.00	16 or 21x24	$3.00
30	9.00	30	9.45	30	3.90
36	9.45	36	9.93	36	3.90
49	9.93	49	10.35	49	5.91
61	10.35	61	10.80	61	7.77

Horizontal Bars :	16" wide sash	$1.14
	21" wide sash	1.23
	25" wide sash	1.35

Casements are also often used in combination with larger fixed units or "picture windows".

Picture Window Units For Casements

Glass Size	Cost glazed with: 1" insul.	11/16" insul.	sheet
35x36	$79.62	$47.34	$41.55
44	95.13	56.64	47.43
55	110.88	66.12	56.52
68	135.06		
75	148.71		
93	172.44		
35x48	100.53	73.05	51.33
44	120.51	82.08	55.89
55	139.95	99.75	65.91
68	166.11		
75	188.46		
93	219.84		
35x60	120.39		65.16
44	140.79		67.53
55	163.05		76.47
68	201.60		
75	219.66		
93	256.56		



Courtesy ROW Window Co.

A panelled study with diamond-grilled casements used either side of a fixed sash.

Prefabricated Bow Window Units

Prices included all casements venting and fitted with screens and SSB units with storm sash.

Glass Size	No. of Units	Cost SSB	Cost ½" Insul.
16x36	3	$171.78	$189.06
	4	227.76	250.80
	5	283.47	312.27
	6	330.48	366.27
	7	377.46	420.27
16x49	3	194.10	214.71
	4	257.19	284.67
	5	320.01	354.36
	6	377.01	418.35
	7	434.01	482.34
16x61	3	212.88	241.41
	4	281.85	319.89
	5	350.52	398.07
	6	414.54	469.08
	7	478.53	540.09
21x36	3	183.45	200.55
	4	242.88	266.16
	5	302.13	331.23
	6	349.11	385.23
	7	396.12	439.23

Prefabricated Bow Window Units—Continued

Glass Size	No. of Units	Cost SSB	Cost ½" Insul.
21x49	3	$205.53	$229.74
	4	271.95	304.23
	5	338.19	378.54
	6	395.19	442.56
	7	452.19	506.55
21x61	3	226.38	256.71
	4	299.37	339.81
	5	372.18	422.73
	6	436.17	493.74
	7	500.19	564.72

Head and seat boards are also available installed. For 16" units add $42.18, $51.18, $70.50, $99.00 and $132.00. For 21" units add $51.75, $60.75, $83.43, $118.32 and $160.86.

Another type of prefabricated bow window is made up of fixed 22" x 18" glass units to form a shallow arc. These run in cost as follows, glazed with ½" insulating glass and with head and seat board a part of the basic unit.

Stud Opng. Height		Width	Cost
4'-8⅞"	x	7'-9"	$248.04
		9'-6¼"	310.26
		11'-3"	384.60
6'-4½"	x	7'-9"	308.07
		9'-6¼"	383.46
		11'-3"	470.52

A further variation of this is a similar unit prefabricated in a flat pattern. It is available glazed, SSB, or ½" insulating.

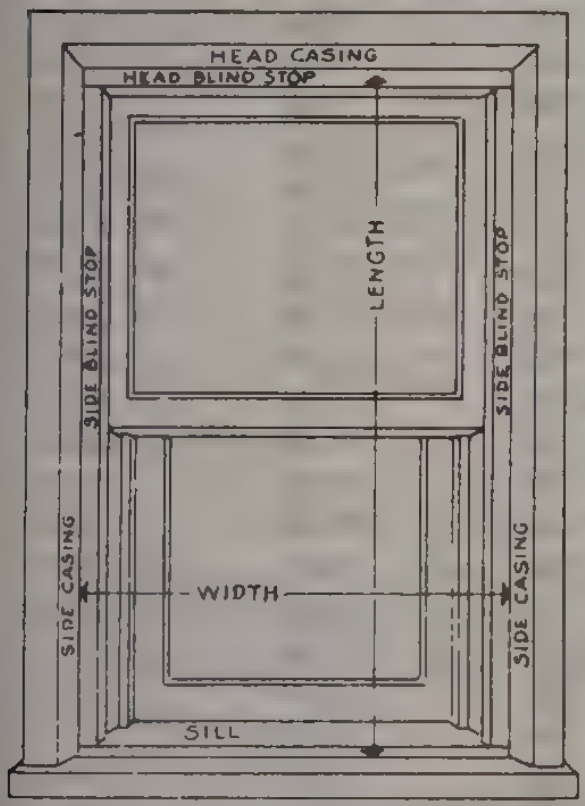
Stud Opng. Height		Width	Cost SSB	Cost ½" Insul.
4'-10¼"	x	7'-8¾"	$122.07	$212.19
		9'-7⅞"	147.06	259.98
		11'-6"	176.25	306.18
6'-4⅞"	x	7'-8¾"	147.09	268.02
		9'-7⅞"	171.54	323.25
		11'-6"	208.68	384.00

Vented sash can be made to replace a fixed sash in both the flat

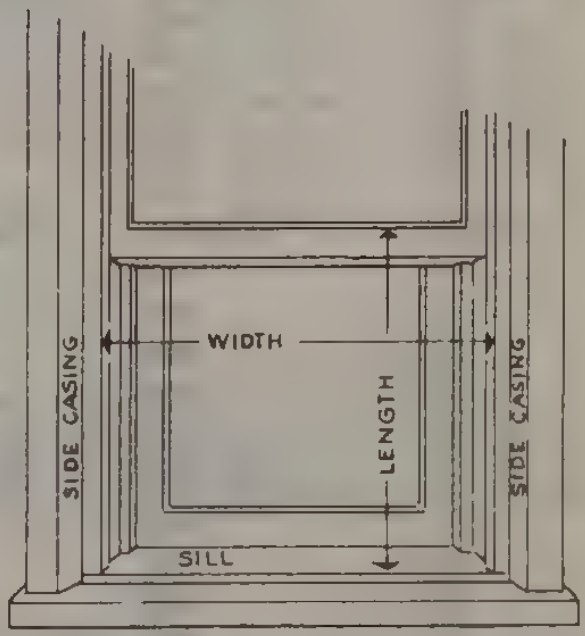
and bow units. Add, including operator and screen, $24.00. Discounts of around 10% are available if ordered with 6 or more other units.

WINDOW SCREENS

Wood window screens have been largely replaced by aluminum units. Most prefabricated wood sash have aluminum screens available to fit them and can be ordered as part of the unit or individually later. The following list gives a sampling of prices.*



Full Screen (order by screen sizes).
Length: Measure the distance from the bottom of the head casing to the sill of the window.
Width: Measure the distance between the side casing of each window.



Half-Screen (order by screen sizes).
Length: Measure the distance from the top of the bottom rail of the top sash to the sill of the window.
Width: Measure the distance between the blind stop of each window.

Glass Size	Full Frame Screen Size	Half Screen Size	Full Frame	Half Screen
16x16	19¾x38¾	18⅝x20¼	$5.04	$3.63
20	46¾	24¼	5.40	3.96
24	54¾	28¼	5.70	4.14
28	62¾	32¼	6.06	4.41
32	70¾	36¼	6.39	4.74
36	78¾	40¼	6.69	5.04

*ROW Window Co.

Glass Size	Full Frame Screen Size	Half Screen Size	Full Frame	Half Screen
20x16	23¾x38¾	22⅝x20¼	$5.40	$3.84
20	46¾	24¼	5.73	4.14
24	54¾	28¼	6.09	4.38
28	62¾	32¼	6.48	4.65
32	70¾	36¼	6.81	4.98
36	78¾	40¼	7.17	5.31
24x16	27¾x38¾	26⅝x20¼	5.67	4.02
20	46¾	24¼	6.06	4.29
24	54¾	28¼	6.45	4.56
28	62¾	32¼	6.84	4.86
32	70¾	36¼	7.26	5.19
36	78¾	40¼	7.62	5.52
28x16	31¾x38¾	30⅝x20¼	5.94	4.14
20	46¾	24¼	6.36	4.53
24	54¾	28¼	6.81	4.80
28	62¾	32¼	7.23	5.07
32	70¾	36¼	7.68	5.43
36	78¾	40¼	8.10	5.82
32x16	35¾x38¾	34⅝x20¼	6.24	4.35
20	46¾	24¼	6.69	4.71
24	54¾	28¼	7.17	4.98
28	62¾	32¼	7.62	5.28
32	70¾	36¼	8.07	5.67
36	78¾	40¼	8.55	6.06
36x16	39¾x38¾	38⅝x20¼	6.48	4.56
20	46¾	24¼	6.99	4.89
24	54¾	28¼	7.50	5.16
28	62¾	32¼	7.92	5.49
32	70¾	36¼	8.46	5.91
36	78¾	40¼	9.00	6.33
40x16	43¾x38¾	42⅝x20¼	6.84	4.68
20	46¾	24¼	7.38	5.07
24	54¾	28¼	7.89	5.40
28	62¾	32¼	8.40	5.73
32	70¾	36¼	8.91	6.15
36	78¾	40¼	9.45	6.60
44x16	47¾x38¾	46⅝x20¼	7.14	4.86
20	46¾	24¼	7.68	5.25
24	54¾	28¼	8.25	5.55
28	62¾	32¼	8.76	5.94
32	70¾	36¼	9.33	6.39
36	78¾	40¼	9.90	6.84

WOOD SLIDING OR PATIO DOORS

Sliding doors are now available from most of the nationally distributed millwork houses, and follow the general designs established for aluminum sliding units. These doors can usually be purchased in two basic widths per panel and in various arrangements including two panels, one fixed, one operating; three panels, two sides fixed and center panel operable; and four panels, two end panels fixed and two center panels operable.

The following price schedule is based on units preglazed with $\frac{5}{8}$" safety glass and complete with operating hardware, weatherstripping, sill, and screens for operable sash.

Glass Size	Stud Opening Width	Stud Opening Height	Type	Cost
28" wide	5'-5¾"	6'-10¼"	Double	$276.00
34" wide	6'-5¾"	6'-10¼"	Double	307.50
46" wide	8'-5¾"	6'-10¼"	Double	373.50
34" wide	9'-8⅜"	6'-10¼"	Triple	444.00
46" wide	12'-8⅜"	6'-10¼"	Triple	537.00

Add for keyed lock, $4.65.

Grilles which may be removed for cleaning are available in either diamond or rectangular patterns. Costs are $15.90 each for the 28" width, $18.15 each for the 34" width, $24.90 for the 46" width in the rectangular pattern; and $22.50, $25.65 and $35.25 each for the diamond patterns.

Solid Wood Paneling

While most paneling used today is of veneered plywood, nothing matches the beauty of solid wood paneling; and its ability to withstand years of usage and often even improve with age.

Solid paneling is usually quoted in random widths of 4" to 8" and random lengths of 6' to 16'. Specified widths and lengths will run 10% or more additional. Traditional thickness is ¾", but much paneling today is available at a considerable savings in ½" thickness.

There is no nationally established grading rules for solid wall paneling, so it is necessary to know the product of the mill quoting to compare prices. Generally, woods are available in two grades: "select," "luxury," or "clear" and "knotty," "wormy" or "pecky," often designated as "colonial" grade.

In figuring paneling, add 15% to actual areas for waste and matching.

Paneling is available with v-joint tongue and groove, square joint, shiplap and colonial beaded.

The most commonly encountered paneling is knotty pine. Cost is around 30¢ per sq. ft.

Clear pine will run around 35¢.

Clear birch in ¾" thickness will run around 90¢ but it is also available in a Colonial grade at around 81¢. Birch is an excellent cabinet wood with a firm texture, but has a rather strong grain pattern.

White ash is an open grained wood, light in color with contrasting light brown heartwood. It is easy to work and somewhat resembles flat grained white oak. It will range from 95¢ for ¾" select grade to 89¢ for Colonial grade.

Butternut, often called white walnut, is a soft-textured, easy-to-nail wood which takes a beautiful natural finish. While available "select," it is generally character marked and will run around $1.10 per sq. ft.

Cherry, cut from the wild black cherry, is a traditional Colonial paneling. It is a firm textured cabinet wood, but is available only in a rather narrow range of sizes. It runs around 55¢ for ½" select down to 45¢ for ½" Colonial.

Oak is available from either white or red varieties cut on the quarter grain. Oak is a very hard wood and subject to shrinkage and splitting in adverse conditions, but well worth the extra effort for the right place. Oak runs 65¢ for the red and 72¢ for the white in ¾" select, 55¢ and 62¢ in ¾" Colonial.

Walnut has become so popular and the sources for it so restricted that it is now a high priced wood and will run $1.65 or better a square foot for ¾" select. As it is a hard wood, ½" thickness is practical and will run 87¢ for select and 67¢ for Colonial. A "wattled" walnut is also sold which is character marked as standardized by the American Walnut Association. It costs 70¢ in ¾" thickness.

Other domestic woods available are maple, around 97¢ for ¾" select and 56¢ for antique; wormy chestnut, at $1.10 for ¾"; and cypress at 50¢ for ¾" select.

Imported woods are also available. The so-called "exotic" woods are more often found in the architectural grade, book-matched plywood where their veneers can be shown off to better advantage.

Some foreign woods stocked in the Chicago area include paldao, a firm textured striped wood for medium brown from the Philippines; African mahogany and the less costly Philippine mahogany which is more difficult to finish; avodire, a light creamy-colored wood which comes from Africa with a roll figure somewhat on the diagonal; limba, or korina, African wood which is cream or tan in color with a darker heartwood, and tigerwood or African lovea, a dullish brown to golden colored wood with a wide or ribbon stripe.

These are all special woods for special jobs and prices and availability should always be checked as they vary considerably, but all are expensive woods.

The following table, listed in order of cost, is a current price list of hardwoods stocked in the Chicago area, select and better, ¼, S4S, 6′ and longer. 5/4 thicknesses will run 1.25 times ¼ prices; 6/4, 1.6 times and 8/4, 2.2 times.

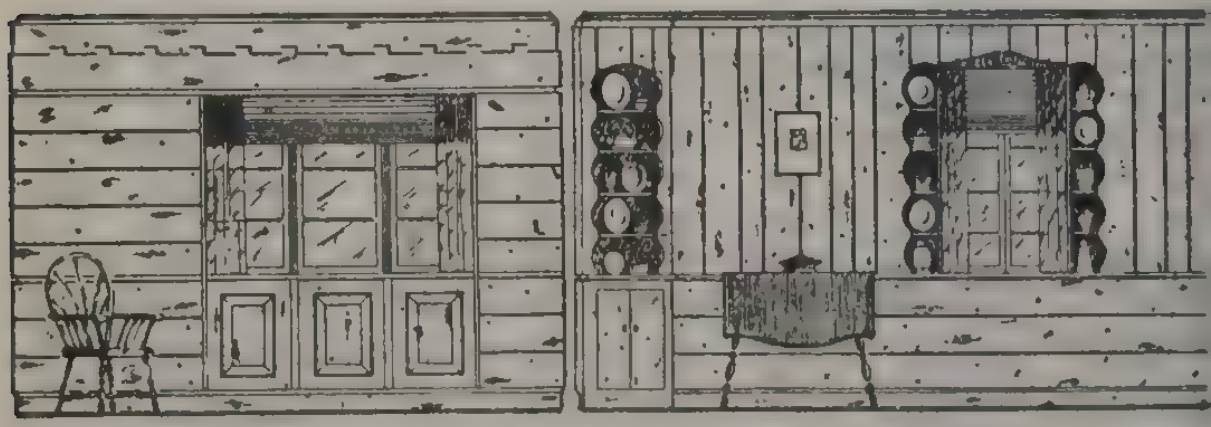
Wood 4/4 Width	1"	2"	3"	4"	6"	8"	10"	12"
Basswood	$0.095	$0.135	$0.20	$0.27	$0.40	$0.62	$0.84	$1.00
Poplar	.095	.135	.205	.27	.41	.625	.85	1.025
Cottonwood	.105	.14	.21	.28	.42	.645	.875	1.05
Sap Gum	.105	.14	.21	.28	.42	.645	.875	1.05
Elm	.11	.15	.225	.30	.45	.690	.94	1.125
Red Oak	.11	.155	.235	.31	.47	.715	.975	1.175
Beech	.115	.155	.235	.31	.47	.715	.975	1.20
Mahogany (Phil.)	.12	.16	.24	.32	.48	.735	1.00	1.20
Soft Maple	.12	.17	.255	.34	.51	.785	1.065	1.275
Hickory	.125	.175	.265	.35	.53	.805	1.10	1.325
Pecan	.125	.175	.265	.35	.53	.805	1.10	1.325
White Oak	.125	.18	.27	.36	.54	.83	1.125	1.35
Ash	.125	.185	.28	.37	.56	.85	1.165	1.40
Hard Maple	.135	.185	.28	.37	.56	.855	1.165	1.40
Cherry	.135	.19	.285	.38	.57	.875	1.19	1.425
Mahogany (African)	.135	.195	.295	.39	.59	.90	1.225	1.475
Birch	.145	.205	.31	.41	.62	.945	1.34	1.70
Afrormosia	.19	.28	.42	.56	.84	1.29	1.75	2.10

Wood 4/4 Width	1"	2"	3"	4"	6"	8"	10"	12"
Butternut	$0.185	$0.283	$0.425	$0.56	$0.85	$1.29	$1.765	$2.125
Chestnut	.185	.285	.43	.57	.86	1.315	—	—
Walnut	.215	.33	.495	.66	.99	1.52	—	—
Teakwood	.44	.69	1.00	1.38	2.00	3.175	—	—

Hardwood Trim

Moulding Type	Ash	Birch	Red Oak	Walnut	Poplar
Jamb Sets					
(⅞x⅝) ¾"x5⅜"	$ 9.00	$ 9.50	$ 7.50	$15.75	$ 6.85
Casing Sets					
(⅞x⅝) ⅝"x2¼"	3.45	4.00	3.10	5.75	3.00
Stop Sets					
(⅞x⅝) 7/16"x1 5/16"	2.40	2.50	2.00	3.10	2.00
Casing* ⅝"x2¼"xR/L	15.75	18.50	13.25	26.25	13.25
Base* ½"x3¼"xR/L	18.00	19.00	14.80	28.50	14.50
Base Shoe* ½"x¾"xR/L	6.50	7.00	5.50	9.50	5.50
Cove* ¾"x¾"xR/L	9.00	9.25	7.25	12.00	7.25
Cove* ¾"x1¾"xR/L	15.75	18.50	13.25	25.00	13.25
Stool* ¾"x3¼"xR/L	24.00	25.25	18.70	—	18.00

*Prices per 100 L. F. on lots to 1000 lineal feet.



Prices below are for birch. Prices for others will run correspondingly more or less.

2-¼" casing	18½¢ per lin. ft.
3-¼" base	19 ¢ " " "
¾" base shoe	7 ¢ " " "
¾" cove	9½¢ " " "
1-5/16" door stop	11¢ " " "
3-¼" stool	25½¢ " " "

Outside Blinds or Shutters

Clear Ponderosa pine, 1⅛" thick.

All shutters have stiles, top and middle rails 2¼" wide; bottom rail 4½" wide. All slats are stationary.

Price per Pair, Ponderosa Pine, Preservative Treated

Window Size	With Fixed Slats	With Raised Panels
2'-0"x3'- 3"	$10.10	$14.25
3'-11"	11.35	16.70
4'- 7"	13.30	19.55
5'- 3"	15.05	22.20
2'-4"x3'- 3"	10.10	14.25
3'- 7"	10.90	15.45
3'-11"	11.35	16.70
4'- 3"	12.45	18.30
4'- 7"	13.30	19.55
4'-11"	14.20	20.90
2'-8"x3'- 3"	10.40	14.75
3'- 7"	11.15	15.95
3'-11"	11.95	17.15
4'- 3"	13.10	18.80
4'- 7"	14.00	20.15
4'-11"	14.95	21.45
5'- 3"	15.85	22.80
3'-0"x3'- 3"	11.00	15.60
3'- 7"	11.75	16.80
3'-11"	12.55	18.00
4'- 3"	13.75	19.65
4'- 7"	14.70	21.10
4'-11"	15.65	22.50
5'- 3"	16.65	23.90
3'-4"x3'- 3"	11.70	16.65
3'-11"	13.30	19.05
4'- 7"	15.65	22.35
4'-11"	16.65	23.85
5'- 3"	17.65	25.30
3'-8"x4'- 7"	16.55	23.60
4'-11"	17.65	25.15
5'- 3"	18.70	26.75

Shutters with raised panels can be fitted with decorative cut outs in the upper panel at an extra cost of $1.45 per pair. Designs include pine trees, cloverleafs, squirrels, crescents and roosters.

Door Blinds

Same as above, except 3 panels of slats in height.

Size	Price
2'-8"x6'-9", per pair	$16.00
3'-0"x6'-9", per pair	18.00

Style "A"

Outside Blinds or Shutters
Style "B"

Style "C"

Steel and Aluminum Shutters

Metal shutters of steel or aluminum are designed to be screwed on the wall permanently. The louver section is stamped out of one piece of metal. They are furnished with one coat of baked on dark green enamel. "B" Shutters are aluminum, "C" Shutters are steel.

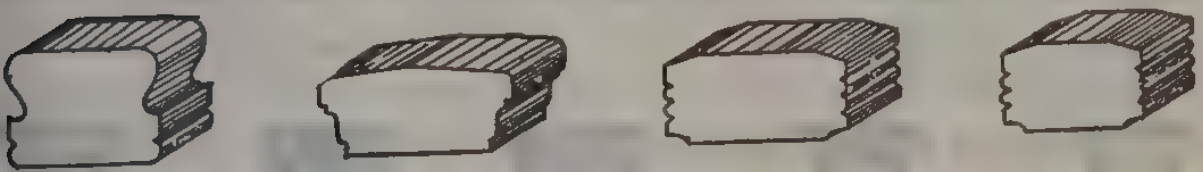
Size of a Pair of Shutters	Weight Pounds	Price per Pair "B"	Price per Pair "C"
2'- 4"x3'- 3½"	14	$ 8.80	$ 6.1
2'- 4"x3'- 7½"	15	9.35	6.4
2'- 4"x3'-11½"	15	9.85	6.5
2'- 4"x4'- 3½"	17	10.50	7.0
2'- 4"x4'- 7½"	18	11.00	7.2
2'- 4"x4'-11½"	18	11.90	7.7
2'- 4"x5'- 3½"	21	12.50	8.2
2'-10"x4'- 3½"	20	11.50	7.7
2'-10"x4'- 7½"	21	12.10	8.3
2'-10"x4'-11½"	23	13.10	8.7
2'-10"x5'- 3½"	24	13.80	9.1
2'-10"x5'- 7½"	25	16.80	11.2
2'-10"x6'- 7½" (Door)	29	19.10	13.0
3'- 4"x4'- 7½"	24	13.20	9.3
3'- 4"x4'-11½"	26	14.30	9.7

Weights given are for steel shutters. Aluminum weighs one half as much as steel.

Molded Shutters

Shutters are now molded of thermo-formed polymer. They are prefinished in either black or white, but may be painted with an exterior latex paint. They are screwed to siding with 2″ aluminum screws, 4 per unit to 55″, 6 per unit over 55″.

Size Per Panel	Price Per Pair 6 Pair Pack	Single Pair Pack
16″x35″	$10.78	$12.07
39	11.34	12.70
43	12.12	13.57
47	13.12	14.69
51	13.89	15.56
55	14.67	16.43
59	15.56	17.43
63	16.67	18.67
67	17.56	19.67
72	18.56	20.79
80	21.12	23.65



Porch Top Rail and Balustrade Cap

Rabbeted Porch Jamb, Plowed Shoe and Bottom Rail

Clear Ponderosa Pine Porch Material

Kind of Molding	Size in Inches	Price per 100 Lin. Ft.
Square Baluster Stock	$1\frac{1}{8}$″x$1\frac{1}{8}$″	$10.20
Square Baluster Stock	$1\frac{3}{8}$″x$1\frac{3}{8}$″	14.40
Square Baluster Stock	$1\frac{5}{8}$″x$1\frac{5}{8}$″	22.40
Balustrade Cap	$3\frac{5}{8}$″x$1\frac{5}{8}$″	38.40
Balustrade Shoe	$3\frac{5}{8}$″x$1\frac{5}{8}$″	38.40
Rabbeted Porch Jamb	$1\frac{1}{2}$″x$3\frac{1}{2}$″	38.40
Plowed Porch Shoe	$1\frac{1}{2}$″x$3\frac{1}{2}$″	38.40
Top Rail	3 ″x$2\frac{1}{4}$″	46.80
Top Rail	$3\frac{3}{4}$″x$1\frac{3}{4}$″	38.40
Bottom Rail	$3\frac{1}{2}$″x$1\frac{3}{4}$″	38.40

Cornice Boards

Select Grade

Prices are per 100 lin. ft. in random lengths 6'-0" to 16'-0".

Measured Size	S4S to	Price
1"x 3"	¾"x2⅝"	$15.00
1"x 4"	¾"x3½"	15.00
1"x 6"	¾"x5½"	22.50
1"x 8"	¾"x7½"	30.00
1"x10"	¾"x9½"	41.70
1"x12"	¾"x11½"	55.00

Wood Columns

Columns for exterior work are made from clear heart redwood staves glued together under clamp pressure with cold water water

ROMAN Wood Cap and Base

DORIC Wood Cap No Base

IONIC Compo Cap Wood Base

CORINTHIAN Compo Cap Wood Base

ATTIC Wood Ca Wood Bas

proof glue. Shafts are turned in the lathe with the correct entasis and to insure uniform stave thickness after turning, the staves are made straight for the lower third of the shaft and swell-tapered for the upper two-thirds thus giving the correct entasis in the rough. Any style of fluting or reeding may be had.

The columns receive a prime coat of lead and oil on the exterior surface and columns over 14" in diameter receive a coat of water-proof asphaltum paint on the hollow core surface.

All columns are furnished with a guarantee as to their workmanship and durability.

No printed price lists are available for these items and each must be priced at the factory. In order of price, the Roman is cheapest followed by the unfluted Ionic, the fluted attic, the fluted Doric and finally the fluted Corinthian. A sampling of prices found a 16" Roman 10' high, would cost around $150.00 f.o.b. factory, while a Corinthian in the same size would cost $225.00. A 20" 20' high Corinthian would cost some $400.00 a column.

Cast Iron Column Bases.—Cast iron column bases keep columns off the floor and permit air to circulate on the inside of the column.

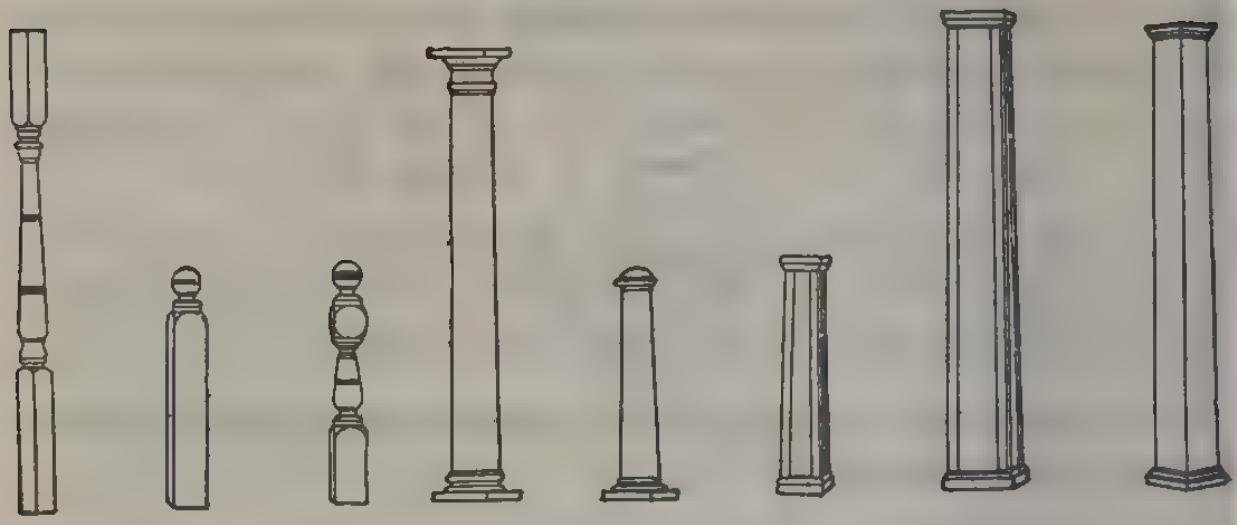
Prices of Cast Iron Column Bases

Base Size	Height	For Col. Diam.*	Wt. Lbs.	Approximate Price
11 "x11 "	2 "	8"	18	$ 7.50
13½"x13½"	2½"	10"	24	10.50
16 "x16 "	2½"	12"	32	13.25
18½"x18½"	2½"	14"	35	15.15
21¼"x21¼"	2½"	16"	54	20.00
24 "x24 "	3¼"	18"	87	26.80
26½"x26½"	3¼"	20"	96	34.80

*For Doric columns without base use one size smaller.

Cast iron bases for pilasters are ⅔ the price of bases for corresponding columns.

Built-Up Wood Columns



Turned and Built-up Wood Columns and Newels

These columns are made from 1¼-inch California redwood with a tongue groove to prevent opening or warping.

Size of Column	Height Column	Round Colonial	Plain Square
6"x 6"	8'-0"	$28.00	$23.00
6"x 6"	9'-0"	32.00	28.00
8"x 8"	8'-0"	36.00	28.00
8"x 8"	9'-0"	37.00	30.00
10"x10"	8'-0"	48.00	39.00
10"x10"	9'-0"	54.00	43.00

Ponderosa Pine Moldings

Prices are per 100 lin. ft. unless noted otherwise.

Aprons
- 11/16"x2¼" ..... $ 9.85
- 11/16"x2¼" ogee 9.85
- 5/16"x3½" 15.15

Astragals
- 1⅜"x7'-0" ..... 2.05 ea.
- 1¾"x7'-0" ..... 2.50 ea.

Backband
- 11/16"x1 1/16" $5.85

Balusters
- ¾"x"¾ 4.35
- 1 1/16"x1 1/16" 9.90
- 1 5/16"x1 5/16" 14.15
- 1⅝"x1⅝" 22.40

Ponderosa Pine Moldings—Continued

Bases
- 9/16"x3" $12.50
- 1/2"x3 1/2" 14.35
- 1/2"x4 1/4" 19.90

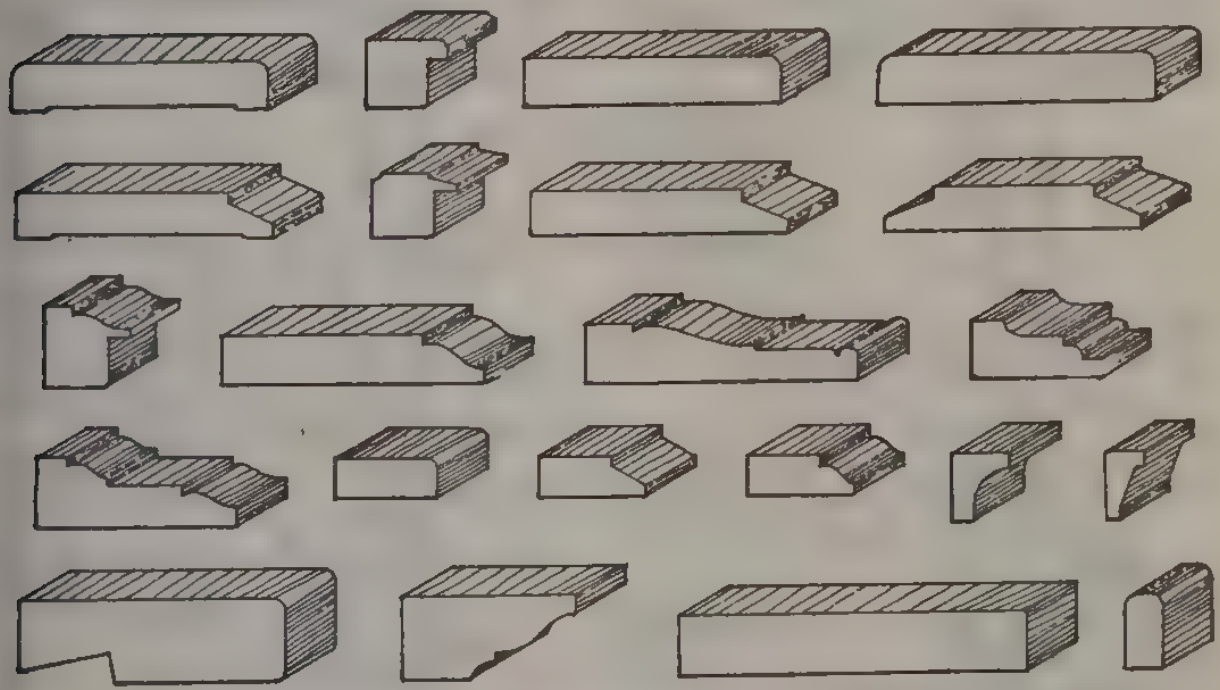
Base Cap
- 11/16"x1 3/8" 7.10

Base Shoe
- 1/2"x3/4" 3.10

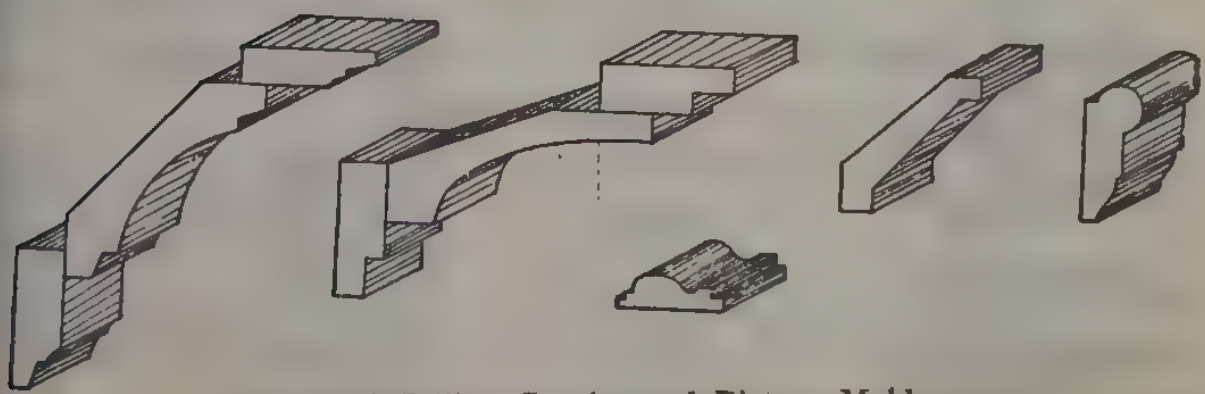
Base Shoe Combination
- 3/4"x2 5/8" $13.65

Bed Molding
- 11/16"x1 3/4" 9.00
- 11/16"x2 1/4" 11.50

Blind Stop
- 3/4"x1 3/8" 7.75



Wood Interior Trim, Casings, Back-band, Stops, Stool, etc.



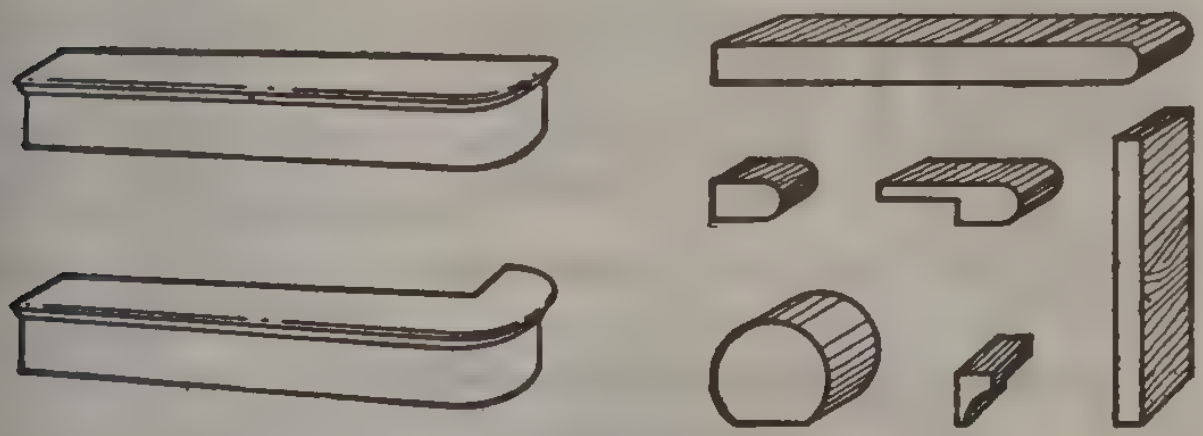
Wood Ceiling Cornice and Picture Mold

Ponderosa Pine Moldings—Continued

Brick Molding	
1 5/16" x 2"	$20.55
Casings	
11/16" x 2 1/4"	9.20
9/16" x 3 1/2"	14.15
Chair Rails	
11/16" x 2 1/8"	10.60
7/16" x 2 1/2"	9.70
Corner Guards	
3/4" x 3/4"	4.35
1 1/8" x 1 1/8"	10.30
1 5/16" x 1 5/16"	14.70
Coves	
11/16" x 3 1/4"	16.30
11/16" x 2 1/4"	11.50
11/16" x 1 3/4"	9.00
3/4" x 7/8"	5.35
3/4" x 3/4"	4.25
1/2" x 1/2"	3.00
11/16" x 1 1/8"	6.10
Crowns	
11/16" x 3 5/8"	18.10
11/16" x 2 3/4"	13.95
11/16" x 2 1/4"	11.50
Drip Caps	
1 1/16" x 1 5/8"	13.65
3/4" x 1 5/8"	9.25
Jamb Extensions	
3/4" x 1 15/16"	11.15
3/4" x 7/8"	5.15
Full Rounds	
1 5/8"	22.40
1 5/16"	14.15
Glazing Beads	
1/2" x 9/16"	3.10
3/8" x 3/8"	2.35
Half Rounds	
5/16" x 5/8"	2.40
Hand Rails	
1 1/2" x 1 3/4"	23.25
Hook Strips	
9/16" x 2 7/16"	11.30
Lattice	
1/4" x 1 1/8"	$ 3.05
1/4" x 1 3/8"	3.55
1/4" x 1 3/4"	4.35
1/4" x 2 1/4"	6.35
Mullion Casings	
9/16" x 5 1/2"	24.80
3/16" x 2"	5.30
Parting Strip	
7/16" x 3/4"	3.05
Picture Molding	
3/4" x 1 3/4"	9.90
Quarter Rounds	
1/4" x 1/4"	2.20
1/2" x 1/2"	3.00
3/4" x 3/4"	3.95
1 1/16" x 1 1/16"	10.30
Screen Moldings	
5/16" x 5/8"	2.40
1/4" x 3/4"	2.20
1/4" x 3/4"	2.20
Screen Stock	
3/4" x 1 3/4"	9.90
3/4" x 2 3/4"	14.70
1 1/16" x 1 3/4"	14.25
1 1/16" x 2 3/4"	22.55
Shelf Cleat	
11/16" x 1 1/2"	7.95
Stools	
1 1/16" x 3 1/4"	26.10
1 1/16" x 3 5/8"	29.25
11/16" x 3 1/4"	15.70
11/16" x 2 3/4"	13.40
11/16" x 2 1/4"	11.05
1 1/16" x 2 1/4"	18.35
Stops	
7/16" x 2 1/8"	7.70
7/16" x 1 5/8"	5.75
7/16" x 1 3/8"	4.80
7/16" x 1 1/8"	4.10
7/16" x 7/8"	3.45
7/16" x 15/16"	3.85
7/16" x 5/8"	2.75

Aromatic Red Cedar Closet Lining

⅜"x2½" per 40 ft., per carton.....$9.00



Inside Stair Materials

Inside Stair Material

Starting Steps

Quarter circle.....	Red Oak.....	4' long	$25.00
Half circle.....	Red Oak.....	4'-6" long	31.05
Bull nose.....	Red Oak.....	4'-6" long	30.70
Scroll end.....	Red Oak.....	4'-6" long	34.55

Stringers (not housed)

¾"x11¼"x 8'-0" long.....	Red Oak	$11.00
x10'-0" long.....	Red Oak	13.00
x12'-0" long.....	Red Oak	21.00
x14'-0" long.....	Red Oak	24.00
x16'-0" long.....	Red Oak	28.00

Treads (not returned; for returns add $1.75)

1⅛"x10½"x3'-0" long.....	Red Oak	$3.65
x3'-6" long.....	Red Oak	4.25
x4'-0" long.....	Red Oak	4.80
1 1/16"x11½"x3'-0" long.....	Red Oak	3.95
x3'-6" long.....	Red Oak	4.60
x4'-0" long.....	Red Oak	5.20
x5'-0" long.....	Red Oak	6.60
x6'-0" long.....	Red Oak	8.35

Inside Stair Material—Continued

Return Nosing
1⅛"x1¾"x1'-2" with 2" return.....Red Oak $1.75

Tread Nosing
1⅛"x1¾"x1'-2" long.....Red Oak 0.70
1 1/16"x1⅛"x1'-2" long.....Red Oak ..... .55

Landing Tread Nosing
1 1/16"x3½"x3'-0" long.....Red Oak 1.25
x3'-6" long.....Red Oak 1.50

Tread Brackets
12"x7¾"x¼" 3 ply.....Nat. Birch 1.05

Newel Posts

	Birch	Red Oak
3¼"x3¼"x3'- 2" tapered, starting—	$11.05	$10.10
x3'-10" tapered, starting—	12.70	
x5'- 3" tapered, landing—	16.50	
x7'- 0" tapered, angle—	22.25	14.75
2¼" diameter 4'-0" long	7.90	6.40
3¼" diameter 4'-0" long	12.80	9.60

Balusters

		Birch	Red Oak
1 5/16" round	30" L.	$ 1.75	$ 1.50
	33"	1.85	1.55
	36"	1.90	1.60
	39" or 42"	2.10	1.90
1 5/16"x1⅜" oval	30"	1.40	
	33"	1.50	
	36"	1.60	
	39" or 42"	1.75	
1 5/16"x1 5/16" square tapered			
	30"	$ 1.75	$ 1.50
	33"	1.85	1.55
	36"	1.95	1.60
	39" or 42"	2.10	1.90

Railings -Natural birch, random length

1¾"x1⅜"	$ 0.60	
1¾"x1 11/16"	.65	
2⅝"x1 11/16"	.90	
2⅛"x2⅜"	1.30	($1.10 in Red Oak

Rail Bolts and Plug .35

	Birch	Red Oak
Volute with easement	$26.70	$23.20
Turnout with easement	16.35	14.35
Easement with newel cap	11.75	9.90
Concave easement	8.60	7.75

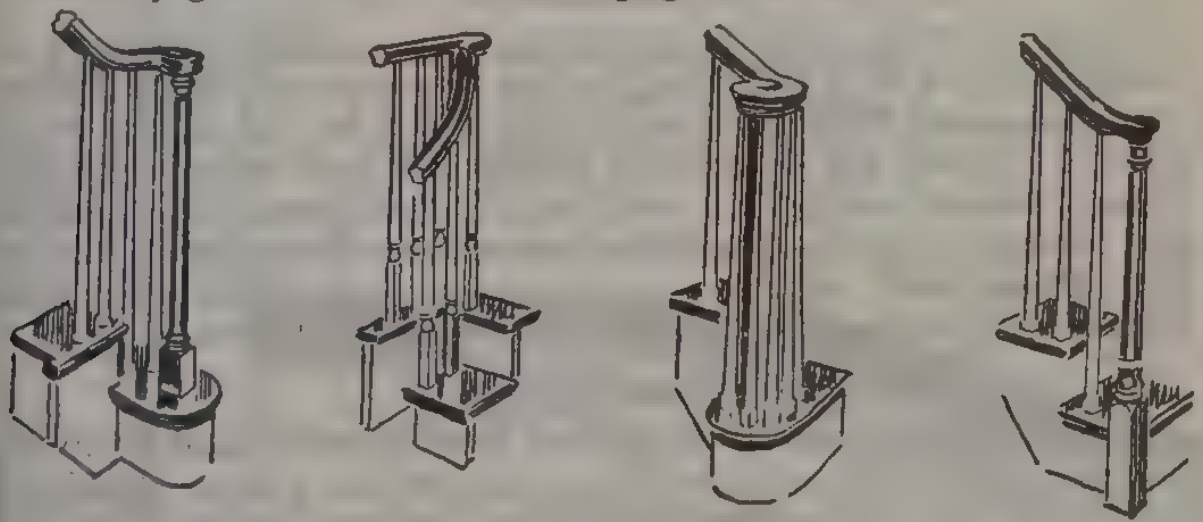
Inside Stair Material—Continued

	Birch
Concave easement 90°	$ 9.80
Convex easement	9.25
Goose neck	13.65
Goose neck & newel cap	17.05
Goose neck ¼ turn & easement	31.35
Level quarter turn	8.60
Newel cap	4.90
Newel cap & one rail outlet	6.15
Vertical volute	15.70
Starting rail drop	14.05

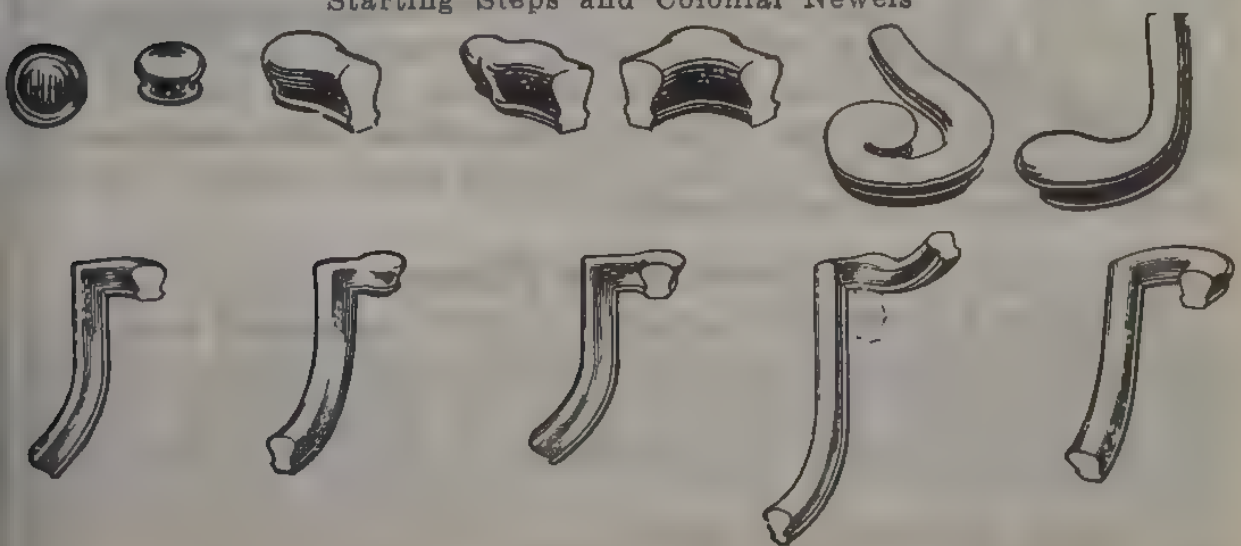
Prefabricated Folding Stairways

For 9′ finished floors to finished ceiling heights:

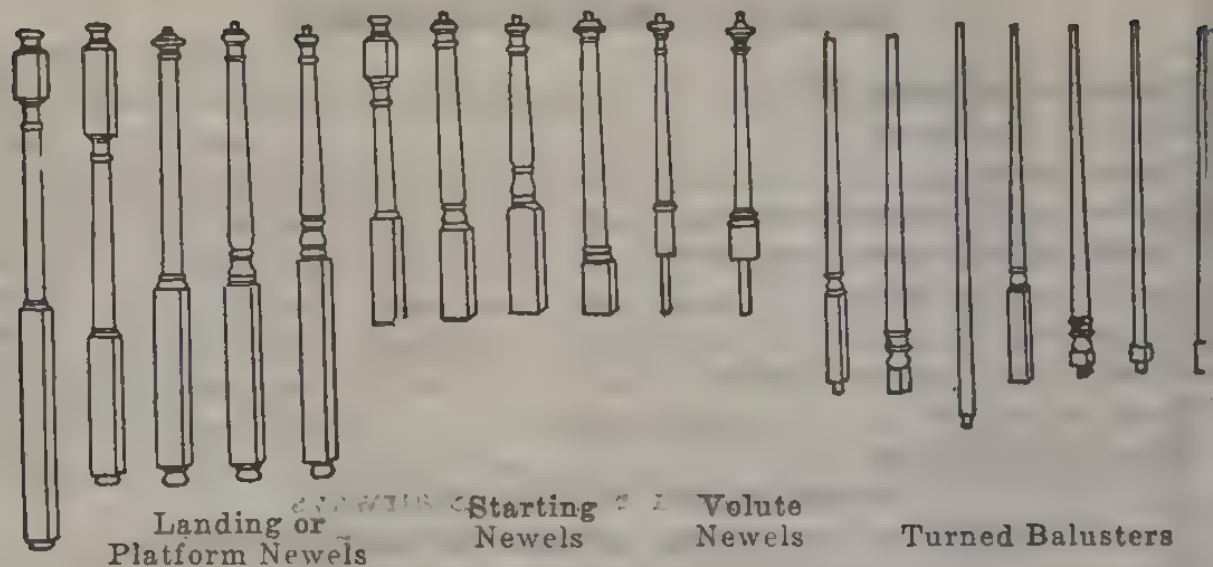
Premium grade: for 2′-6″x6′-0″ opng	$210.00
Medium grade: for 2′-2″x4′-6″ opng	65.00
Economy grade: for 2′-2″x4′-6″ opng	30.00



Starting Steps and Colonial Newels



Railing Fittings



Turned Colonial Stair Newels and Balusters

Mantels

There are many stock mantel designs from which to choose. A simple molding 6" wide extending out from the wall 2" on 3 sides will run around $45 for an outside dimension of 4'x7'. A full mantel with 7" shelf and of colonial design will cost from $75 to $85. More elaborate designs in Georgian or French provincial and with end returns to fit over the brick projection will run from $100 to $125. These costs are for wood members only. Brick or marble trim around the fireplace opening are, of course, extra.

China Cabinets

Corner cabinets can be purchased from stock to add architectural interest to dining, breakfast or recreation rooms. Mostly of Ponderosa pine with either Colonial or Georgian design, they will vary from $85 for a unit 2'-8" wide with single doors top and bottom to $140 for a unit 3'-6" wide with double doors. Cabinets are from 7' to 7'-6" high. Bottom doors are usually paneled, top factory glazed. Shipped with front assembled and body knocked down, the unit includes 3 shelves for the upper portion, 1 for the lower. Hardware is not included.

Ironing Board Cabinet

A built-in feature which appeals to most housewives is an ironing board cabinet unit complete with adjustable board plus sleeve board, all operating hardware, and flush door which is sized to fit between wall studs 16" on centers. It is shipped in a carton and costs around $45. The door is available in either birch or Philippine mahogany. No casing is included, but if the unit is set in a matching paneled wall, it is almost inconspicuous.

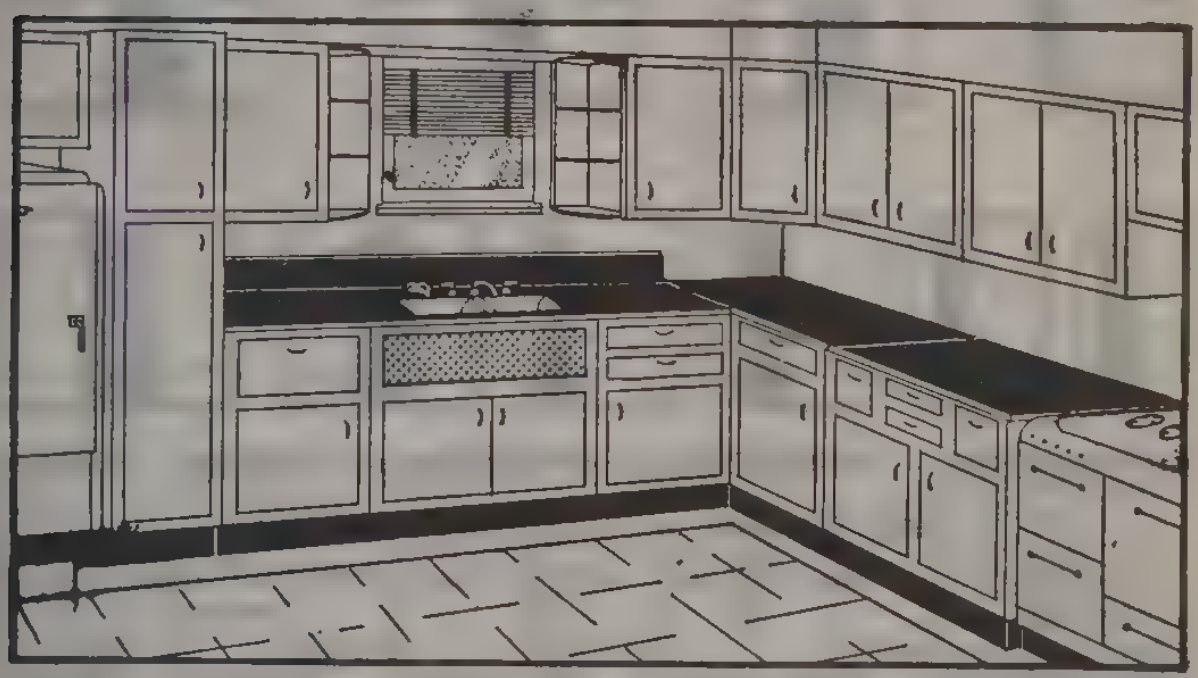
Flush Cupboard Doors

Flush cupboard doors are made with composition cores of resin coated and impregnated wood chips and flakes fused together under heat and pressure. Cores are sandwiched between birch veneer and are finished with 1½" basswood edge strips on the long edges.

Plain Birch—¾" Thick

Widths Not Over	Length 1'-0"	1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"
1'-0"	$1.10	$1.65	$2.15	$2.70	$3.25	$3.80	$4.35	$5.40	$6 50	$7.60	$8.65
1'-2"	1.65	2.15	2.70	3 25	3.80	4.85	5 40	6.50	7.60	9.20	10.25
1'-4"	1.65	2.15	3.25	3.80	4.35	5.40	5.95	7.55	8.65	10.25	11.90
1'-6"	1.65	2.70	3.25	4.35	4.85	5.95	6.50	8.10	9.70	11.35	13.00
1'-8"	2.15	2.70	3.80	4.85	5.40	6.50	7.55	9.20	10 80	13.00	14 60
1'-10"	2.15	3.25	4.35	5.40	5.95	7.05	8.10	10.25	11.90	14.00	16.20
2'-0"	2.15	3.25	4.35	5.40	6.50	7.55	8.65	10.80	13.00	15.10	17.30

WOOD KITCHEN CASE UNITS



Wood Kitchen Cases

The following cases are furnished completely assembled and finished. Frames are ¾" kiln dried hardwood; doors and drawer fronts are ⅞" thick birch veneer with solid lumber cores; shelves are ½" plywood; backs of base cabinets are Masonite; backs of wall cabinets and drawer bottoms are plywood; ends of cabinets are flush with hardwood faces.

Cabinets are factory finished with a penetrating sealer coat.

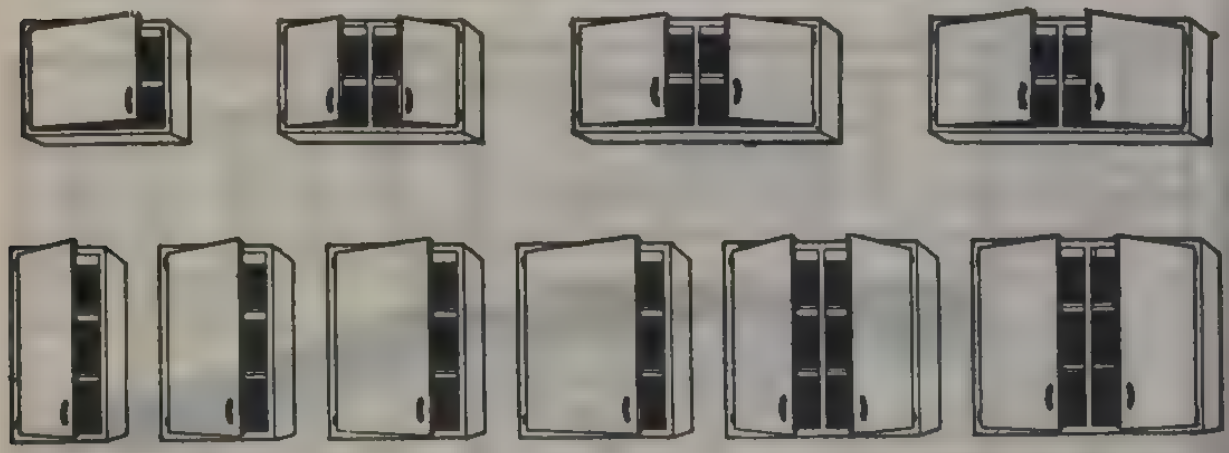
shellac and hot clear lacquer. Interiors are finished and drawer bottoms are clear lacquered.

Base cabinets are available with or without stainless steel edged Formica tops.

Door and drawer hardware has hammered wrought iron effect with an antique gold finish.

These cases are considered medium quality and are the type found in most residential construction. Economy grade cases for cheaper speculative construction will range from 50 percent less in price, for unassembled and unfinished units, to 25 percent less for finished units ready for installation. For top quality kitchen cases, the prices will run up to 50 percent higher for stock sizes and 100 percent higher or more for custom made units, depending upon the design, materials, hardware and finish specified.

All prices are f.o.b. factory in Indiana.



Top Sections or Wall Units.

Top Sections or Wall Units, 14" Deep

Wall units 15" and 18" high have 1 fixed shelf; 30" high 2 fixed shelves.

Width	No. Doors	13" High	18" High	30" High
12"	1	$....	$....	$35.00
15"	1	....	....	38.00
18"	1	....	....	40.00
21"	1	....	....	44.00
24"	2	34.00	39.00	48.00
27"	2	....	40.00	55.00
30"	2	35.00	45.00	60.00
33"	2	37.00	46.00	61.00
36"	2	41.00	51.00	65.00
42"	2	44.00	53.00	71.00

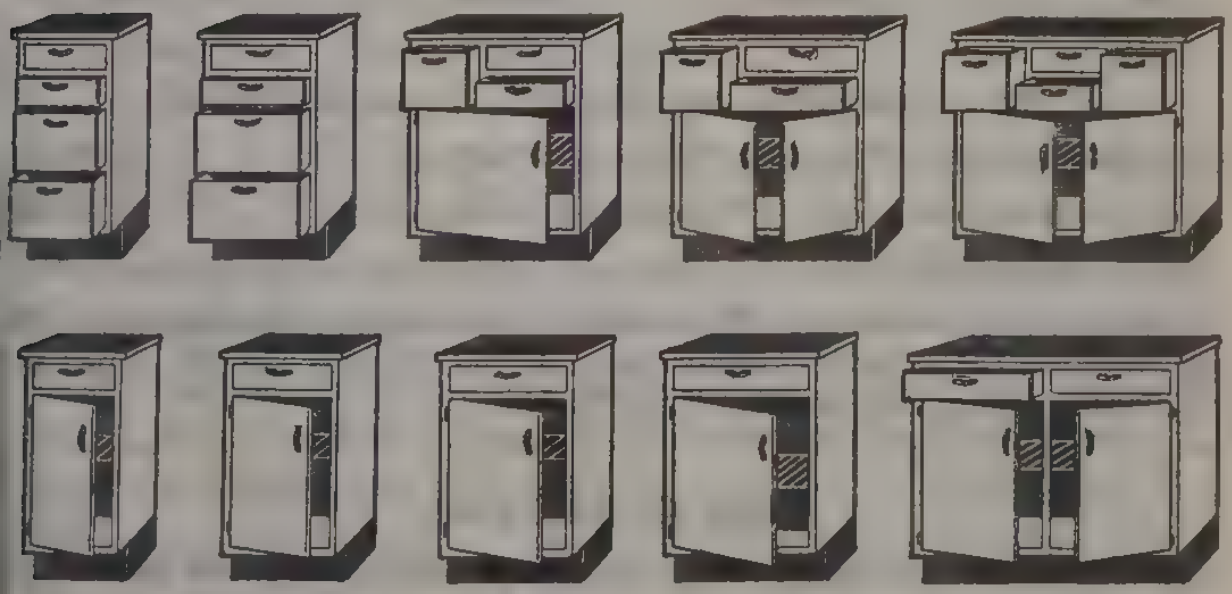
Corner Shelf and Wall Units, 30" High

Corner wall unit, 23" deep and wide, with 2 fixed shelves	$ 63.00
Corner wall unit, 23" deep and wide, with revolving 3 shelf "Lazy Susan"	101.00

Wood Cabinet Base Units

Base units are 34½" high and 23¾" deep without tops.

Width Inches	Description	Without Tops
15"	4 drawers	$ 68.00
18"	4 drawers	73.00
24"	4 drawers	79.00
30"	4 drawers	96.00
12"	1 top drawer, 1 door below	48.00
15"	1 top drawer, 1 door below	50.00
18"	1 top drawer, 1 door below	54.00
21"	1 top drawer, 1 door below	56.00
24"	1 top drawer, 1 door below	63.00
27"	2 top drawers, 2 doors below	72.00
36"	2 top drawers, 2 doors below	82.00
42"	2 top drawers, 2 doors below	86.00
48"	2 top drawers, 2 doors below	92.00
42"	Corner base cabinet	69.00
35"	Corner base cabinet with revolving "Lazy Susan"	112.00
	1"corner filler	3.50



Wood Cabinet Base Units

Wood Sink Fronts

Description			Width	Price
Sink front only	1 pair doors		21"	$25.00
" " "	"	"	24"	27.00
" " "	"	"	27"	28.00
" " "	"	"	30"	30.00
" " "	"	"	33"	32.00
" " "	"	"	36"	33.00
" " "	"	"	42"	37.00
" " "	2 pair doors		48"	49.00
Sink end			24"	8.00

Complete Wood Sink Units

Assembled sink and base units to match cabinets and bases. 34½" high by 23" deep, without tops. 36" high and 24" deep with tops. Sink units have 4" back-splashers and are complete with sink and fittings.

Width Inches	Price Without Tops or Sinks	With Tops, 4" Back-splashers, Sinks and Fittings FORMICA TOPS Single Bowl	Dbl. Bowl
54"	$ 63.45	$131.00	$ .....
60"	66.45	136.00	148.80
66"	69.55	142.30	155.10
72"	73.35	148.15	160.95
84"	87.70	168.10	180.85

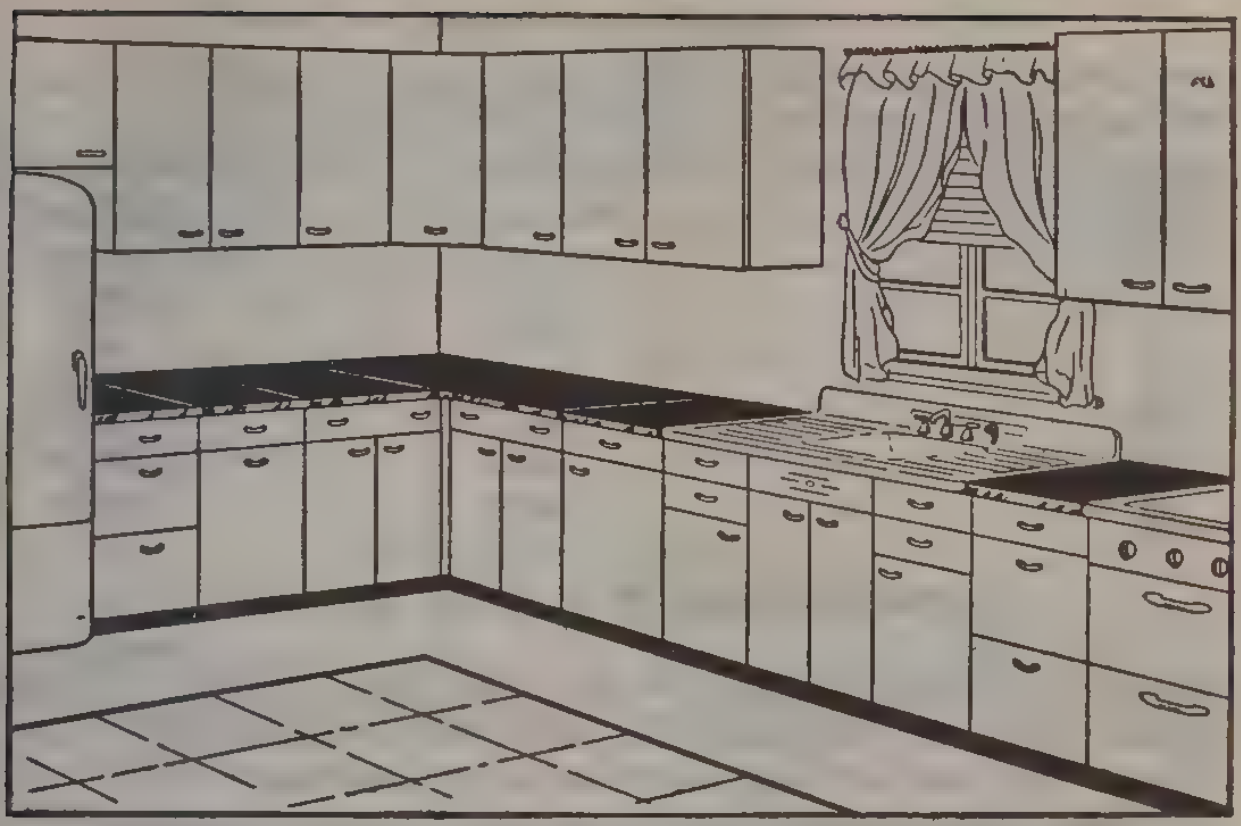
Utility Cabinet and Built-In Oven Cabinets

Utility cabinet, 84" high, 23" deep, 18" wide. .....$ 90.00
Oven cabinet, 84" high, 23" deep, 24" wide. 128.00
Oven cabinet, 84" high, 23" deep, 27" wide. 138.00

The above cabinets have flush doors. Decorative moldings may be applied to these faces. Moldings cost $14.70 per 100 ft. Special curved sections for corners cost 50¢ each.

Steel Kitchen Units

Prices on steel case units vary considerably with different manufacturers, due to weight of metal used, method of manufac-



Steel Kitchen Cases

turing, kind of finish, sprayed or baked and volume of production as many kinds of steel cases are on a mass production basis, while others are custom made to fit the job. Naturally, the custom cabinets cost more.

The cabinets priced below are completely finished and ready to be installed. They are fabricated from 18, 20 and 22 gauge cold rolled steel and are spot welded, bonderized and then finished with 2 coats of white synthetic enamel baked on at high temperature. They are medium quality.

Base units are mounted on an integral black enameled subbase 4″ high and recessed 3″ in front for toe space.

Doors are ¾″ thick, double-walled, die formed of one piece of steel and spot welded. Drawers have ¾″ fronts which make them flush with the doors. Drawers operate on roller bearings.

Hardware consists of semi-concealed hinges. Die-cast chromium plated handles are furnished on doors and drawers.

Steel Wall Cabinets

Wall units are 13" deep. 18" units have 1 removable shelf; 30" units have 2 shelves.

Width	No. Doors	18" High	30" High
12"	1	$.....	$24.00
15"	1	.....	25.00
18"	2	25.00	29.00
21"	2	27.00	32.00
24"	2	29.00	33.00
27"	2	.....	36.00
30"	2	31.00	37.00
36"	2	36.00	43.00

Corner Shelf and Wall Units, 30" High

Description	Price Each
Corner shelf unit, 12¼" deep, 6" wide, with 2 fixed shelves	$8.00
Corner shelf unit, 12¼" deep and wide, with 2 fixed shelves	9.00
Corner wall unit, 21" deep and wide, with revolving 3-shelf "Lazy Susan"	40.00

Steel Base Cabinets

Base units—36" high and 25" deep with Formica tops, with 4" high back splashers.

Width	Description	Without Top	Formica Top
12"	1 drawer above, 1 door below	$45.00	$ 53.00
15"	1 drawer above, 1 door below	50.00	60.00
18"	1 drawer above, 1 door below	55.00	67.00
21"	1 drawer above, 2 doors below	58.00	72.00
24"	1 drawer above, 2 doors below	65.00	81.00
27"	1 drawer above, 2 doors below	70.00	90.00
30"	1 drawer above, 2 doors below	75.00	95.00
36"	1 drawer above, 2 doors below	84.00	108.00
18"	3 drawers	80.00	92.00
33"	Corner base cabinet with revolving "Lazy Susan"	80.00	104.00

Steel Sink Fronts

Description	Width	Price
Sink front only—one pair doors	24"	$27.00
Sink front only—one pair doors	30"	28.50
Sink front only—one pair doors	36"	30.00

Fillers and End Panels for Steel Cabinets

Description	Price Each
Corner wall filler, 30" high, 15" deep, 15" wide	$ 9.00
Straight wall filler, 18" high, 13" deep, 3" wide	3.25
Straight wall filler, 30" high, 13" deep, 3" wide	3.50
Corner base filler, 34½" high, 27" deep, 27" wide, without top.	5.25
with Formica top.	29.00
Straight base filler, 34½" high, 3" wide	2.25
End panel, 34½" high, 25" deep.	5.50

Steel Kitchen Sink Units

Sinks are 36" high, 25" deep. Constructed of 18, 20 and 22 ga. furniture steel with a baked on synthetic finish. Sink tops are 14 ga. deep drawn enameling steel to which porcelain enamel is bonded.

Tops have grooved drainboards and 4" back-splashers, all insulated to deaden noise. Chromium plated swinging spout mixing faucet, hot and cold water valves and vegetable spray. Sink tops are one piece construction, roll rimmed.

Length Unit	Size Bowl	Single or Dbl. Bowl	Price Each
42"	20"x16½"x7"	Single	$140.00
54"	20"x16½"x7"	Single	160.00
66"	2-14½"x17½"x7"	Double	180.00

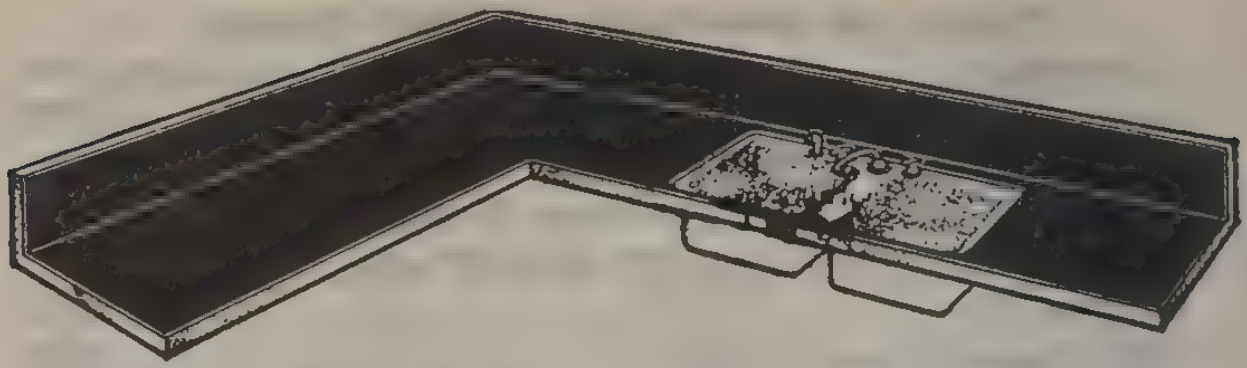
Custom Built Sink Tops

Cabinet or sink tops consisting of a plywood base covered with Formica and having a metal or Formica edging.

Tops can be made, with or without back splashers, and for either single or double bowl sinks.

When figuring length of "L" or "U" shaped tops, measurements should be taken along back edges and figure as a straight top.

Prices given for sink tops with 4" back splashers, also include single or double bowl sinks and fittings.



Length Not Over	CABINET TOPS Formica	SINGLE BOWL Formica	DOUBLE BOWL Formica
24"	$14.00	$.....	$.....
36"	21.00	.....	.....
48"	28.00	.....	.....
60"	35.00	77.00	93.00
72"	42.00	85.00	101.00
84"	49.00	93.00	109.00
96"	56.00	101.00	117.00
108"	63.00	109.00	125.00
120"	70.00	117.00	133.00
132"	77.00	125.00	141.00
144"	84.00	133.00	149.00
Each Add'l 6"	4.10	5.15	5.15

For back splashers higher than 4", add $1.70 per additional inch in height (any length).

Diagonal inside corner on "L" shaped top, add $2.70.

For end splashers, add $6.00 each.

For 4" back splashers on cabinet tops, add $1.10 per lineal foot or fraction thereof.

For half round or quarter round ends, add $4.00.

For rounded corners, 1" radius, add $2.70 each.

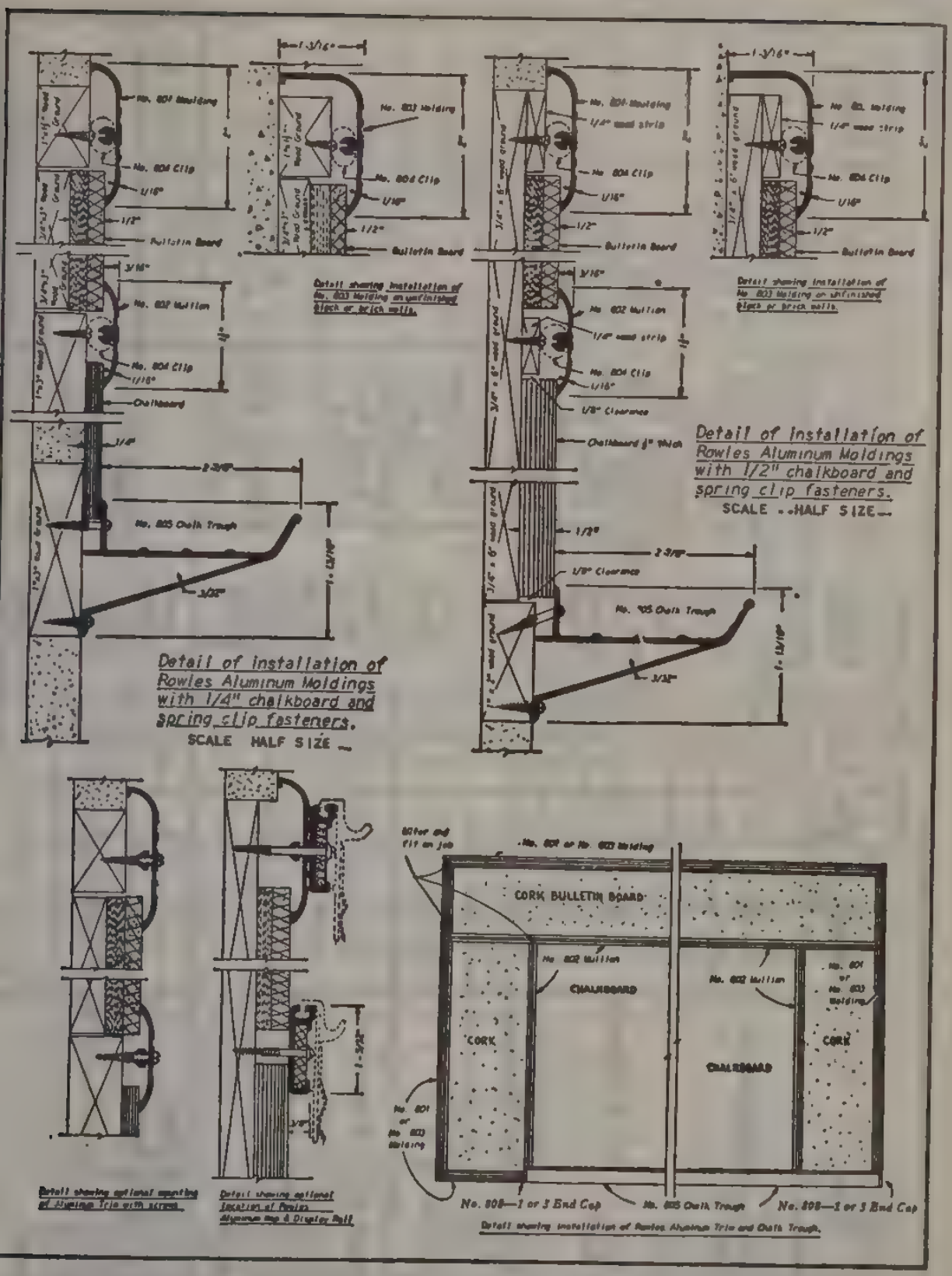
For built-in range cutout, add $3.40.

Chalkboards*

There are many qualities of chalkboards available. The least expensive is made of hardboard and the price ascends through special purpose board, cement asbestos board to porcelain steel boards which may be backed with fiberboard, pulpboard or, for premium grade work, steel backed plywood.

Cement for mounting board costs $3.50 per gal. Joint strips finished to match boards are available at from 70¢ to 85¢ each.

*Courtesy Weber Costello, 1900 N. Narragansett Ave., Chicago


No. 801 Moulding
No. 804 Clip
1/16"
1/2"
Bulletin Board
No. 803 Moulding
Detail showing installation of No. 803 Moulding on unfinished block or brick walls.
No. 802 Mullion
Chalkboard
3/16"
2-3/16"
No. 805 Chalk Trough
3/32"
Detail of installation of Rowles Aluminum Moldings with 1/4" chalkboard and spring clip fasteners.
SCALE HALF SIZE
1/4" wood strip
1/8" Clearance
Chalkboard 3/4" thick
Detail of installation of Rowles Aluminum Moldings with 1/2" chalkboard and spring clip fasteners.
SCALE HALF SIZE
Detail showing optional mounting of Aluminum Trim with screws.
Detail showing optional location of Rowles Aluminum Map & Display Rail
CORK BULLETIN BOARD
CHALKBOARD
CORK
No. 808—1 or 3 End Cap
No. 805 Chalk Trough
Detail showing installation of Rowles Aluminum Trim and Chalk Trough.

Details of Aluminum Moldings Used with Chalkboards and Corkboards

Sheet Chalkboard

Type	Gauge	Wt. Lbs. Per Sq. Ft.	List Price	Standard Colors	Special Colors	Lengths	Heights
Porcelain Steel on Hardboard with Foil Back ¼"	28	2.1	$1.47	Litesite, Green, Black	White, Blue, Coral, Tan	4', 6', 8', 10', 12' 16' available in 24 & 28 gauges only	3½', 4'
	24	2.3	1.78	Green, Black	Dark Green, Blue, Tan, Coral		
	20	2.5	2.03				
Porcelain Steel on ⅜" Pulpboard with Steel Back	28	2.5	1.79	Litesite, Green, Black	White, Blue, Coral, Tan	4', 6', 8', 10', 12' 16' available in 24 & 28 gauges only	3½', 4'
	24	3.0	2.15	Green, Black	Dark Green, Blue, Tan, Coral		
	20	3.5	2.36				
Porcelain Steel on ¼" Plywood with Steel Back	24	3.0	2.35	Green, Black	Dark Green, Blue, Tan, Coral	4', 6', 8', 10', 12'	3½', 4'
	20	3.5	2.56				
Porcelain Steel on ½" Fiberboard	24	2.0	1.67	Green, Black	Dark Green, Blue, Tan, Coral	4', 6', 8', 10', 12'	3½', 4'
	20	2.5	1.88				
Porcelain Steel on ½ Fiberboard, Steel Back	24	2.5	2.19	Green, Black	Dark Green, Blue, Tan, Coral	4', 6', 8', 10', 12'	3½', 4'
	20	3.0	2.40				
Ultra Dense Cement Asbestos		2.5	1.40	Litesite, Black		6', 8', 10', 12'	3½', 4'
Cement Asbestos		2.5	1.20	Green, Black	Brown, Blue, Coral, Olive Gr.		
½" Special Purpose Board		1.8	.69	Litesite, Black		4' to 16'	3½', 4'
¼" Special Purpose Board		2.7	1.05				
¼" Hardboard		1.8	.59	Green, Black	Blue, Brown, Coral, Olive Gr.	4' to 16'	3½', 4'
½" Hardboard		2.5	.93				
¼" Hardboard		1.5	.45	Green, Black		4' to 12'	3½', 4'

	Item	Board Size	Stock Lengths	Ship. Wt. Per Lin. Ft.	Per Lin. Ft.
Snap On Trim	Perimeter Trim	½"	8'4", 10'4", 12'4"	⅓ lb.	$0.47
		¼"			.45
	Map Rail w/Insert	½"	12'0"	½ lb.	.77
		¼"			.73
	Mullion		12'0"	¼ lb.	.29
	Mullion Map Rail w/Insert		6'0", 8'0", 10'0", 12'0"	⅓ lb.	.55
	Chalktrough	½"	8'0", 10'0", 12'0", 16'0"	1 lb.	1.41
		¼"			1.37
	Chalktrough Closure	½"		¾ lb.	.90 ea.
		¼"			.80 ea.
	Concealed Clips	½"			.10 ea.
		¼"			.10 ea.
Slip On Trim	Perimeter Trim	½"	8'6", 12'6", 16'6"	¼ lb.	.34
		¼"	10'3", 14'3", 16'3"		.32
	Map Rail w/Insert	½"	8'6", 12'6", 16'6", 21'6"	½ lb.	.60
	Mullion Map Rail w/Insert		6'0", 8'0", 10'0", 12'0"	⅓ lb.	.55
	Chalktrough		8'0", 12'0", 16'0", 21'0"	½ lb.	.86
	"H" Joining Trim ¼"		12'0"	¼ lb.	.47
	"H" Joining Trim ½"		12'0"	¼ lb.	.49
	Mounting "L" Clip			1 oz. ea.	.10 ea.
Screw On Trim	Head Trim	½"	8'4", 10'4", 12'4"	⅓ lb.	.43
		¼"			.41
	Map Rail w/Insert	½"	12'0"	½ lb.	.65
		¼"			.55
	Mullion		12'0"	¼ lb.	.29
	Mullion Map Rail w/Insert		6'0", 8'0", 10'0", 12'0"	⅓ lb.	.55
	Chalktrough	½"	8'4", 10'4", 12'4", 16'8"	1 lb.	1.26
		¼"			1.19
Accessories	Nylon				.30 ea.
	Aluminum				
	Map Hook—Paper Holder				
	Flag Holder				1.75 ea.
	Map Roller Brackets				3.50 pr.
	End Stop for Map Rail				.30 ea.

Most chalkboards are applied directly to the wall and trimmed on the job. Trim is anodized aluminum for snap-on, slip-on and screw-on applications.

Factory built framed units are available. Porcelain steel boards on ⅜" pulpboard with backing using snap-on trim with map rail will run $3.90 per sq. ft. in 3' heights, $3.55 in 3½' and $3.35 in 4' heights. ½" hardboard set with slip-on trim will run $2.25, $2.10 and $2.00 respectively.

Tackboard material may be ordered for job installation in various materials running from 31¢ to $1.50 per sq. ft. Factory assembled boards in 1' heights for use above chalkboards run from $2.85 to $3.75 per sq. ft. In heights from 3' to 4' the cost is $1.90 to $2.50 per sq. ft.

Bulletin board with aluminum trim, glazed door with piano hinge and lock, tackboard back and mounting brackets, cost $110.00 for 30"x36" single door unit; $149.00 and $165.00 for 48"x36" and 60"x36" double door units; and $180.00 for 72"x36" triple door units.

Directory boards are available glass enclosed or open-faced. Glass door units cost $145.00 for 36"x30", $195.00 for 36"x48", and $169.50 for 36"x48" combination tack and bulletin board.

Open faced directory boards cost as follows:

12"x18"	$10.95
18"x18"	15.50
24"x18"	17.95
24"x36"	34.50
36"x24"	34.50

CHAPTER XVII

WALLBOARD, INTERIOR FINISH FIBERBOARD, INSULATION, SOUND DEADENING, BUILDING BOARD AND SHEATHING, CORK INSULATION AND WEATHER STRIPS

The numerous types of wallboard, building board, hardboard, presdboard, tileboard, tile planks, etc., that are used for both new and remodeling work in all class of structures, renders it highly important that every carpenter and contractor possess a thorough knowledge of this important subject if he is to prepare accurate estimates of both materials and labor.

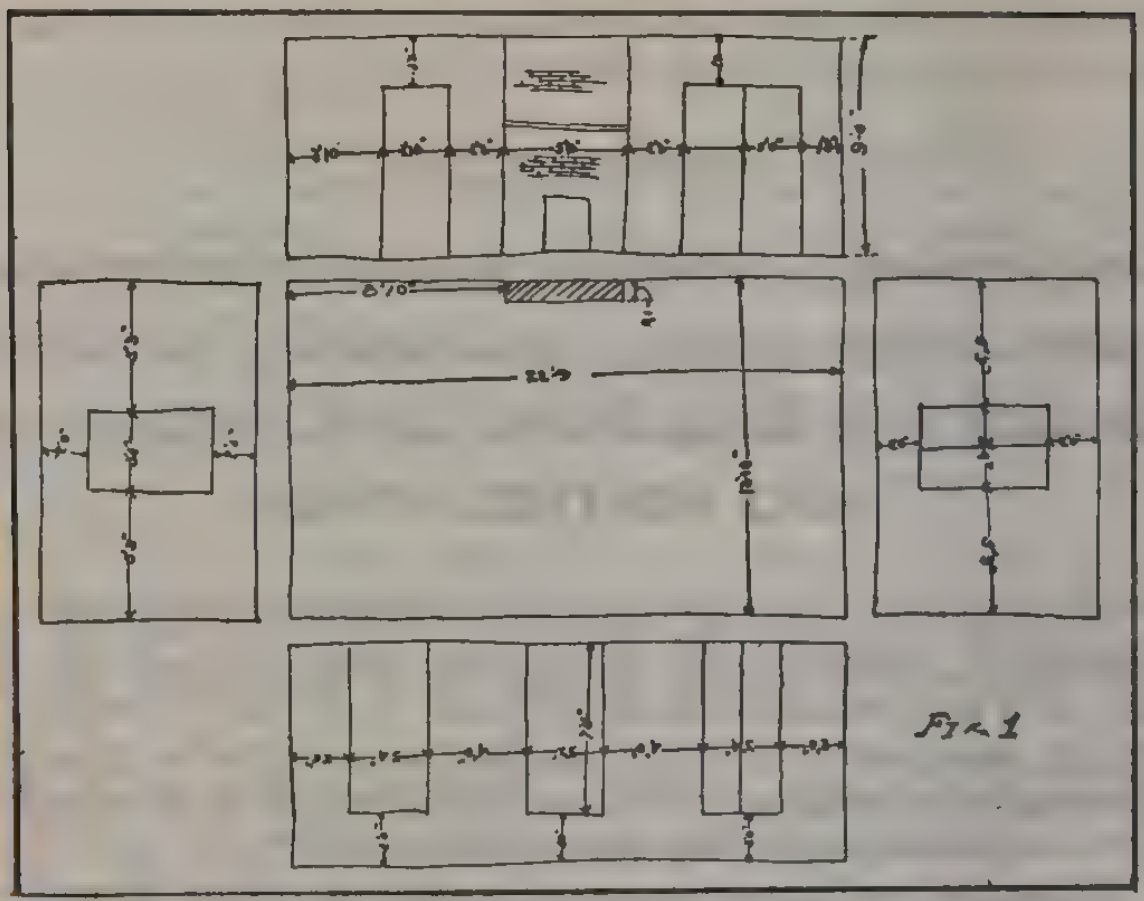
Estimating wallboard is more of a task than merely computing the number of sq. ft. of surface to be covered. Each room should be laid out to obtain certain panel effects as the design of the panels will govern to a certain extent the amount of cutting and fitting necessary.

The labor cost of applying wallboard depends upon three things: the cost of placing headers and nailing strips between wood studs to which wallboard and decorative strips are nailed; the cost of installing the wallboard and the cost of placing decorative panel strips or other means of concealing joints. When installing a ceiling, furring must be applied to provide nailing pieces for all edges of the decorative strips.

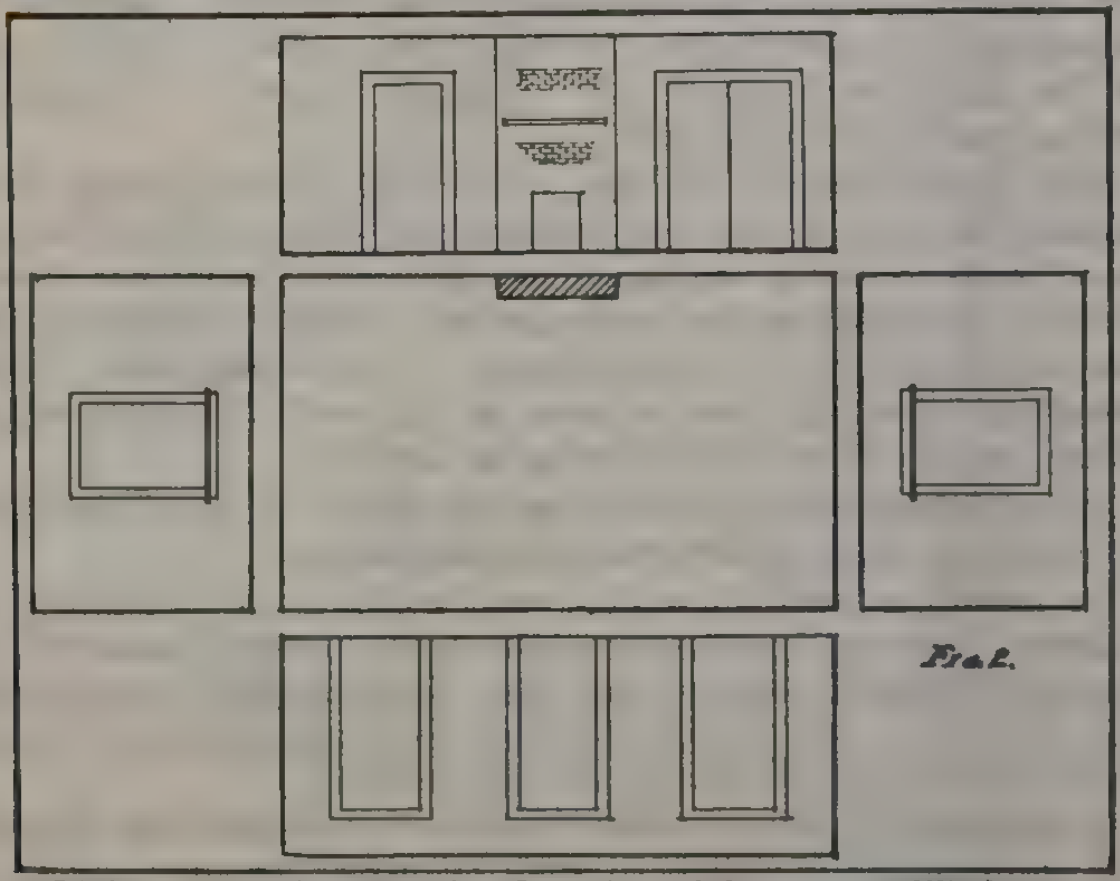
Wood decorative or panel strips are usually $\frac{1}{4}$" to $\frac{1}{2}$" thick and of widths to meet architectural requirements.

In more commercial work, metal moldings of aluminum or stainless steel are used to conceal joints, corners, angles, etc., instead of wood moldings. This type of decoration is used in restaurants, bars, cafes, stores, soda fountains, beauty parlors, barber shops, store displays, bathrooms, kitchens, etc.

Estimating Wallboard Quantities.—When estimating remodeling work, make a sketch of each room, if possible, giving an



Rough Sketch of Room Showing Location of Doors and Windows.



Finished Drawing Showing Location of Doors and Windows.

elevation of each of the four walls and a plan showing the ceiling, similar to that illustrated. From this it is possible to obtain the number of lin. ft. of "headers" or nailing strips required, the size of each piece of wallboard, as well as the number of lin. ft. of panel strips and moldings necessary to complete the job.

Placing "Headers" or Nailing Strips.—When placing "headers" or nailing strips to receive wallboard, it is necessary to cut them to length and place them flush with the face of the studs, as the wallboard must be nailed top and bottom to the "headers" and at the sides to the wood studs.

If the studs are not wide enough to form nailing pieces for the panel strips, a piece of wood, usually 1"x1", must be nailed to either side of the stud along the entire length and flush with the face of the stud.

When estimating this class of work, care should be taken to obtain the exact number of lin. ft. of "headers" required as this is an important item in the cost of the work.

With studs spaced 16" on centers, a carpenter should cut and place 225 to 275 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	3.2	$.....	$.....	$6.75	$21.60
Cost per lin. ft.					.22

Placing Furring Strips for Ceilings.—Furring strips should be nailed at right angles to joists. Any convenient width of furring may be used but it must be wide enough to provide a nailing base to nail all edges of the decorative strips at least every 6". Furring may be of any No. 2 material, soft wood being preferable. Make sure that all furring strips are level.

With joists 16" on centers, a carpenter should cut and place 300 to 350 lin. ft. of furring strips per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.5	$.....	$.....	$6.75	$16.88
Cost per lin. ft.					.17

Placing Wallboard.—The actual cost of placing wallboard will vary with the size and shape of the room, whether full size sheets may be used or considerable cutting and fitting necessary. It requires practically as much time to place a sheet of wallboard 16"x96" as one 48"x96" on account of the cutting and fitting, while there are three times as many sq. ft. in the latter as in the former.

On straight work, in large rooms, a carpenter should fit and place 450 to 550 sq. ft. of wallboard per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.6	$.....	$.....	$6.75	$10.80
Cost per sq. ft.			.....		.11

When applying wallboard in smaller rooms requiring considerable cutting and fitting around doors, windows, etc., a carpenter should fit and place 275 to 300 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.7	$.....	$.....	$6.75	$18.23
Cost per sq. ft.			.....		.18

As previously mentioned, it usually costs more to place a small piece of wallboard than a large one, as this generally calls for cutting and fitting above and below windows, around door openings, etc., that requires considerably more work than placing a large piece of wallboard where no cutting and fitting is necessary. For this reason, estimating the labor cost by the sq. ft. is not the safest method to use, although it is the most common.

Where time in estimating is not a factor, the safest method is to lay out the work as illustrated on the previous pages, dividing it into panels and then allow 20 to 30 minutes to place each piece of wallboard, depending upon the class of work.

Panel Strips and Moldings For Use With Wallboard.—Strips for working out decorative effects on walls or ceilings and for concealing the joints of wallboard may be of the same material as the wallboard or they may be of wood or metal, depending upon the effect desired.

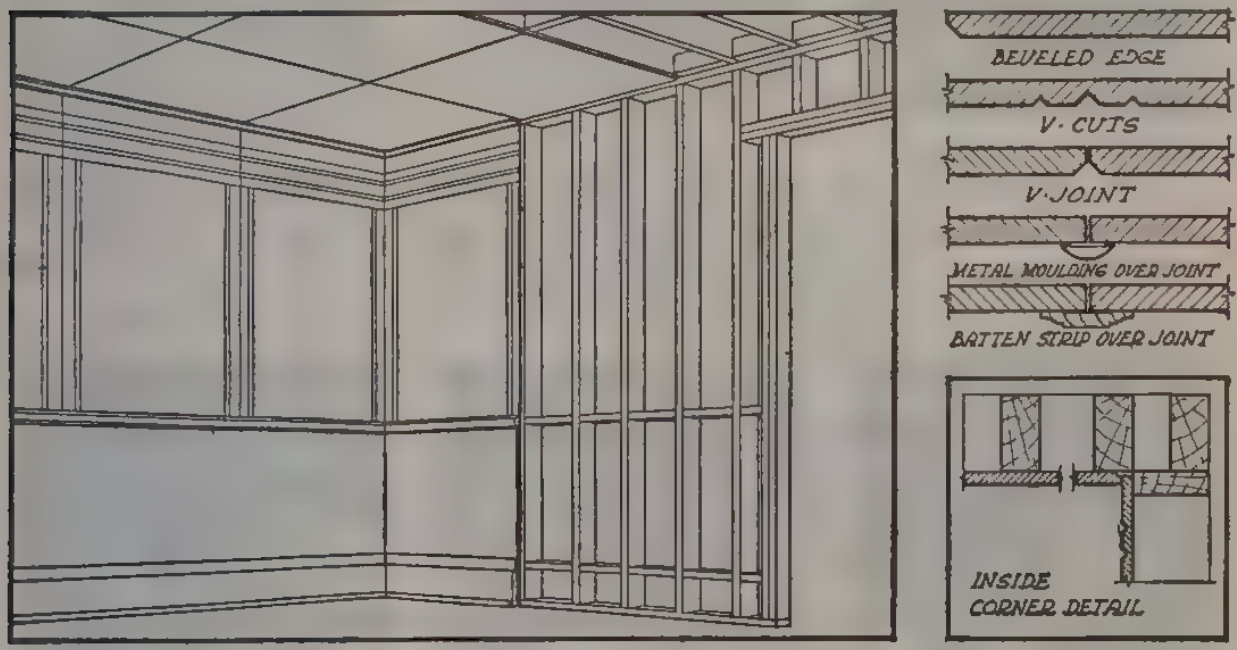
The labor cost of placing wood or composition decorative strips over the wallboard will vary with the design of panel strip used, whether it consists of one, two or three members, the size of the panels and the design of the walls and ceilings, as the more cutting and fitting required the fewer lin. ft. of strips a man will place per day.

On straight work, using an ordinary panel strip $\frac{1}{4}$"x2" to $\frac{1}{2}$"x3", a carpenter should fit and place 350 to 450 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50
Cost per lin. ft.			.....		.14

On more complicated work, using a 1-member panel or decorative strip, a carpenter should place 275 to 325 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.7	$.....	$.....	$6.75	$18.23
Cost per lin. ft.			.....		.18



Modern Method of Applying Wallboard and Treating Joints.

Placing 3-Member Decorative or Panel Strips.—When the panel strips form a plain wall and ceiling design but consist of 3 members (a strip 3" or 4" wide with a small molding on each side) a carpenter should fit and place 150 to 175 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	5	$.....	$.....	$6.75	$33.75
Cost per lin. ft.			.....		.34

Placing Wood Ceiling Beams, Cornices, Etc.—In rooms having beam ceiling effects, wood ceiling cornices, etc., a carpenter should fit and place 175 to 200 lin. ft. of each member per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	4.3	$.....	$.....	$6.75	$29.03
Cost per lin. ft.			.....		.29

Three member cornices would cost 3 times the above price, 4 member, 4 times, etc.

Applying Wallboard Over Existing Plastered Walls and Ceilings.—In remodeling work where the wallboard is applied over existing walls and ceilings, it is advisable to remove the existing

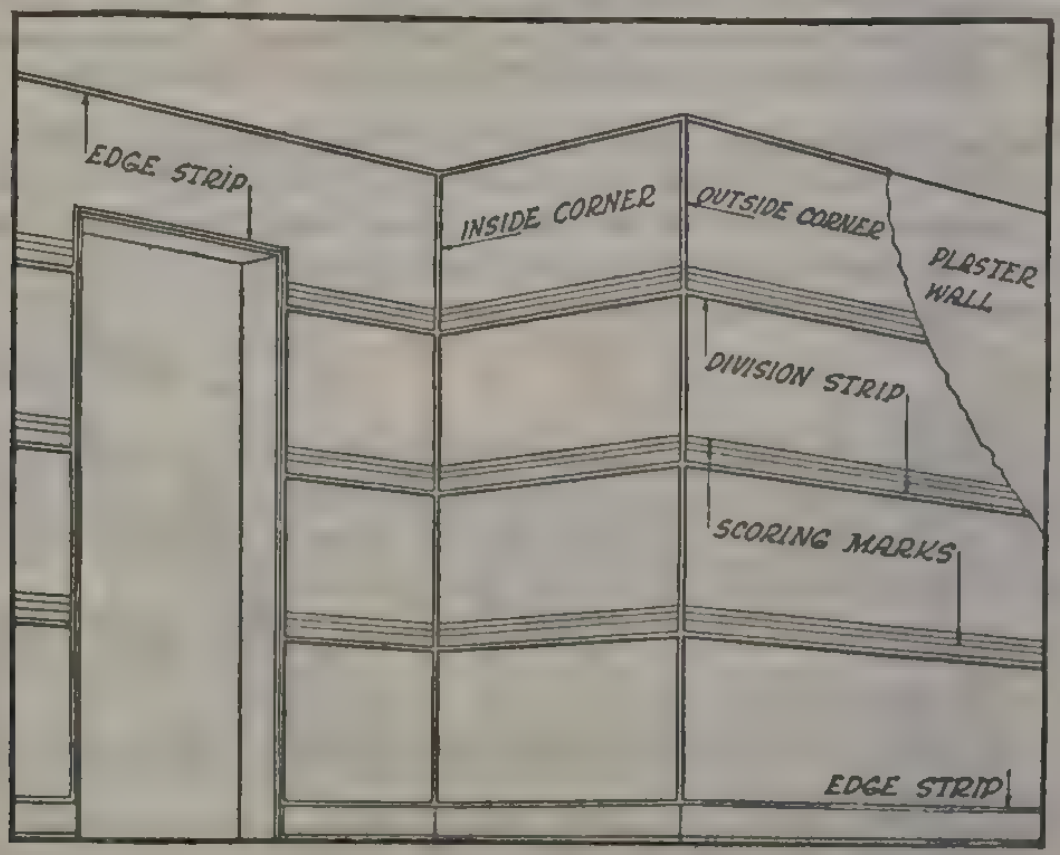
plaster wherever possible. This is inexpensive, seldom costing over $15 to $18 a room and makes a much better job. To obtain a first class job it is recommended that all interior trim, such as door and window casings, base, etc., be removed before applying the wallboard. It is also recommended that furring strips be placed over all existing plastered walls, as this will straighten the walls and provide a much better base for securing the wallboard.

After the furring strips have been placed, the cost of applying the wallboard will run about the same as given on the previous pages.

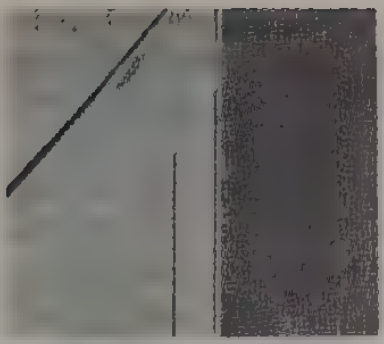
The labor cost of placing wood furring strips is given on the previous pages under "Placing Furring Strips for Ceilings."

Tileboard.—Same as wallboard except it has impressed in one face 4"x4" squares to represent tile. Figure same material quantities and labor costs as given for wallboard under similar conditions.

Kinds of Wallboard.—There are many kinds of wallboard, fiberboard and gypsum board now on the market making it impossible to describe all of them in detail in a book of this kind. Some are made of wood pulp, wood fiber, cane fiber and



Method of Placing Wallboard and Horizontal Scoring Marks and Division Strips.



1. Apply furring strips horizontally, 16" o.c. Rabbet inside corner edge of panel 3/16" to provide a method of fastening and for inserting panel on opposite wall.

2. Start paneling at an inside corner. Plumb and fit first panel accurately, using locator panel on opposite wall to obtain correct position of two corner panels. Then nail first panel to furring strips through rabbet.

3. Insert spline molding at right edge of first panel and nail to furring with 3d coated nails.

4. Slide second panel into position over spline and continue progressively with splines and panels.

5. Rabbet edges of corner panels similarly to accept corner molding. Then nail into furring as shown.

6. Outside corner molding fits evenly into rabbeted edges. Nail through predrilled pilot holes. Set and fill.

Method of Applying 16" Wide Plastic Laminate Panels.

7. Position ceiling molding at top of panel and nail through face with 3d coated finish nails. Set and fill.

Courtesy The Formica Corp.

some of gypsum compositions, manufactured under slightly different methods and varying slightly in appearance but all used for the same general purpose and all selling at approximately the same price for competing materials.

All Beaver products are manufactured by the Certain-teed Products Corp.; Canec boards by the Pioneer-Flintkote Co.; Celotex boards by the Celotex Corp.; Fir-Tex by the Fir-Tex Insulation Co.; Flintkote boards by the Flintkote Co.; Gold Bond boards by the National Gypsum Co.; Insulite products by the Insulite Co.; J-M Board by Johns-Manville; Nu-Wood products by the Wood Conversion Co.; Simpson boards by the Simpson Logging Co.; Temlok boards by the Armstrong Cork Co.; Tempered Presdwood, Presdwood and Presdwood Temprtile by the Masonite Corp.; Upson Fibre Wall Board by the Upson Co.; U. S. G. Insulating Board by the United States Gypsum Co.,; etc.

Prefinished Panels.—New developments in wallboards have been most noticeable in prefinishing and the consequent care needed in concealing nailing.

One of the most popular items is V-grooved hardwood, prefinished with a baked-on finish. Grooves are generally random but with a groove every 16″ on center to hit a stud. Most boards are $\frac{1}{4}$″ thick in sheets 4′ wide by 8′, 10′ or 12′ long. These sheets should be applied over a backing board for first class work. Colored nails are available as well as prefinished moldings for cornices, trim and base. Similar paneling is also available in $\frac{7}{16}$″ thickness for application directly to studs. A wider range of finishes is generally available in the heavier material.

For work subject to more abuse, plywood panels faced with laminated plastics are available. The Formica Company makes a "V.I.P." wall paneling in 16″ wide sheets, $\frac{7}{16}$″ thick in stock lengths to 12′. Special splines are available to provide a normal V-groove, a $\frac{1}{4}$″ wide stained reveal or a $\frac{1}{2}$″ wide reveal with a laminate strip of matching or contrasting color.

The accompanying cut shows the simple application. Aside from excellent wearing qualities, this system offers a wide range of color and design selection, as it is available not only in wood designs, but also solid colors and some printed designs. Some manufacturers of these panels provide metal clip attachments 3′ on center which can be supplemented with adhesives for greater holding power. Splines and battens, for either surface or flush mounting are other ways of handling joints. A complete line of corner cap, ceiling, crown, base and casing moldings is usually available.

A much less expensive prefinished paneling is plastic coated masonite such as Marlite and Royalcote. This comes in $\frac{1}{8}$" and $\frac{1}{4}$" thick panels, $\frac{1}{4}$" thick grooved planks, or as $\frac{5}{8}$" thick tongue and groove 2′ wide boards. This latter is designed for application direct to studs. The thinner boards should have solid backing for first class work. These panels have a wide range of printed designs from wood grains, solid colors, scenic designs, and marble textures. A full line of aluminum and presdwood moldings is available colored to match or compliment the selected material.

A recent innovation is vinyl surfaced gypsum wallboard. This comes in $\frac{3}{8}$", $\frac{1}{2}$" and $\frac{5}{8}$" thicknesses, 8′, 9′ and 10′ lengths. It can be applied with direct nailing with colored nails; glued to furring with a combination adhesive-nail on system, or laminated to a base layer of gypsum backed board. An advantage of this finish is that it can be patched and eventually painted.

Open Work Panels.—A popular addition to stock partitioning available today are panels with open work. These vary from $\frac{1}{8}$" thick prefinished masonite to solid walnut grilles ranging as high as $14 a square foot. The amount of openings can vary from 15% to 50%. These materials make good room dividers and help control sun and glare at windows and cut air conditioning and drapery costs.

The masonite product is known as Filigree and is available in a series of sizes up to 4′x8′ sheets. Prefinished frame sections $\frac{3}{4}$" thick and $1\frac{1}{2}$" wide, factory grooved to receive the panel are available.

Sculptured hardwood panels $\frac{1}{4}$" thick are manufactured by the Penberthy Lumber Co., Los Angeles, in a variety of woods and vary in cost from redwood with sapwood averaging $2.40 per sq. ft. to walnut at $5.25. These are not finished, but may be ordered so. Another source for similar decorative wood panels is Custom-wood Manufacturing Co., Albuquerque, New Mexico. Matching frames for these panels are also available.

Wallboard—Kinds, Sizes and Costs.—There are so many kinds and sizes of wall and insulating board, it is impossible to list all of them.

The thinnest boards are made of wood fiber and are usually furnished in sheets 4 ft. wide, 6 to 12 ft. long, and $\frac{1}{8}$", $\frac{3}{16}$", $\frac{1}{4}$" and $\frac{3}{8}$" thick and prices vary from 11 cts. per sq. ft. for the $\frac{1}{8}$-in. up to 20 cts. per sq. ft. for the $\frac{3}{8}$" board.

Insulating and building board is usually furnished $\frac{3}{8}$ and $\frac{1}{2}$-in. thick, 4 ft. wide and 6, 7, 8, 9, 10 ad 12 ft. long, all having square edges. Some manufacturers furnish a board 1-in. thick

consisting of two thicknesses of ½-in. board glued together with waterproof glue. Board of this type will cost 11 cts. per sq. ft. for the ⅜-in. and 14 cts. per sq. ft. for the ½-in. thickness.

Insulation Board Finish Plank.—Used for interior finish to combine insulation and decoration in one material.

Insulating plank are ½-in. thick and furnished in random widths 8, 10, 12, and 16 in. wide and 8, 10 and 12 ft. long. The long edges may be shiplapped with either a plain bevel or bead and bevel design, as illustrated or have a blind nailing flange.

Plank ½-in. thick cost about 30 cts. per sq. ft. Wall plank with acoustical properties is also now available in 8′ and 10′ lengths. One such product is Cushiontone as manufactured by the Armstrong Cork Co.

Plank Effect Board.—The Plank effect board is ½″ thick, 4′-0″ wide and 8′-0″ high. A series of 5 score lines on each edge and through the center of the board, gives the effect of 3 planks 16″ wide. It may be applied vertically or horizontally either over old plaster or directly to studs. All edges are flush for butt jointing.

The board is painted ivory color on one side. Cost 30 cts. per sq. ft.

Concealed Nailing Clips.—Provide an invisible means for attaching tile or plank to nailing base—clips fit into tongue and groove. Usually packed 1,000 to a carton. Four pieces are required for each 16″x16″ tile. Prices per 1,000 pieces.....$6.00

Use 2d common coated nails with clips. One pound required per 1,000 clips.

Cement or Mastic.—Waterproof cement or mastic for installing insulating plank. One gallon required for 80 to 100 sq. ft. Price per gal.....$3.50

Nails Required for Applying Fiberboard, Tile, Plank, Wainscot and Moldings

For Material ½-in. Thick	Gauge of Nails	Length of Nails	Spacing Directions
Board	No. 17	1¼″	3″
Tile	No. 17	1¼″	6″—10″
Plank	No. 17	1¼″	6″
Wainscot	No. 17	1¼″	6″
Moldings	No. 15	1¼″	6″

As a general rule, board, plank and wainscot require about 6 brads per sq. ft. or 4 to 5 lbs. of 1¼″ brads per 1,000 sq. ft. Galvanized wire brads are recommended. When they are not available, bright wire brads may be used.

Placing Insulating Plank.—The labor cost of placing insulating plank will vary with the surface to which it is applied, length of walls, amount of cutting and fitting necessary, etc. Ceiling work costs more than wall work on account of working on a scaffold and placing the plank overhead.

The most economical method of application is to a solid backing of plywood, wood boards or to other satisfactory nailing surface, as it is necessary to have nailing facilities every 8, 10, 12 or 16 inches, depending upon width of the plank. In the event a solid backing is not available, it is necessary to place wood furring strips to provide for nailing the boards at edges and at ends, also for chair rails, wainscot cap and other ornamental strips.

For plank without blind nailing flange nail through face or bead of the plank, never through bevel. Bury nail heads below surface with properly gauged hammer blow or with a nail set.

The cost of wood blocking and furring is given on previous pages of this chapter.

Number of Sq. Ft. of Insulating Plank of Various Widths Placed Per 8-Hr. Day by One Carpenter, When Nailed In Place

Add for wood furring strips or other backing.

Width of Plank In.	Height of Wainscoting in Feet			
	4'-0"	6'-0"	8'-0"	10'-0"
8	210—260	275—315	315—365	325—390
10	240—300	300—360	360—420	375—450
12	275—340	350—410	410—475	425—500
16	300—360	375—440	450—525	465—525

When applied to ceilings, reduce above quantities approximately 25 per cent.

Carpenter Hours Required to Place 100 Sq. Ft. of Insulating Plank On Walls When Nailed In Place

Add for wood furring strips or other backing.

Width of Plank In.	Height of Wainscoting in Feet			
	4'-0"	6'-0"	8'-0"	10'-0"
8	3.5	2.8	2.4	2.3
10	3.0	2.5	2.0	1.9
12	2.6	2.1	1.8	1.8
16	2.5	2.0	1.7	1.7

When applied to ceilings, add approximately 25 per cent to the above hours.

Insulating Tile

Tile made of Celotex, Fir-Tex, Insulite, Nu-Wood, Temlok and other fiber composition are used for wall and ceiling finish. They

are furnished with beveled edges either square or with a blind nailing or stapling flange. They come in sizes from 12"x12" to 16"x32" and may be used for obtaining ashlar effects on walls and tile effects on ceilings.

They may be applied to wood backing or to furring strips with adhesive, nails, staples or special clips on the walls or ceilings. When furring strips are used, the strips must be spaced to work out with the tile sizes.

In applying square edged tiles, nails should be driven through the tile at an angle to the surface of approximately 60 degrees. Reverse the angle of half the nails and nail through the face of the tile, never through the bevel. Bury nail heads below the surface with properly gauged hammer blow or with nail set.

When applying tiles with blind nailing or stapling flanges, drive the nails or staples in the thick part of the flange perpendicular to the surface.

Insulating fiber tile ½-in. thick cost $150.00 to $210.00 per 1,000.

Nailing Recommendations for Square Edged Fiber Tile.—Where nailing is to be exposed, galvanized wire brads are recommended. When they are not available, bright wire brads may be used. 1¼" brads or finishing nails should be used for exposed nailing of ½" thick tile.

Nailing Recommendations for Square Edged Fiber Tile

Tile Size in Inches	Location of Brads	No. Brads per Tile	Approx. Lbs. Brads 1,000 Sq. Ft. Tile
12x12	1 in each corner	4	3½
12x24	4 in each long edge	8	3½
16x16	3 on 2 opposite edges 3 on center line	9	4
16x32	5 on each long edge 5 on center line	15	3½

Nailing Recommendations for Flanged Tile.—Where attachment of flanged tile is to be by nails, 3d blued lath nails 1⅛" long should be used. Where application is by means of staples, rust resistant staples ½" or $\frac{9}{16}$" in length should be used in conjunction with a gun type stapler.

Tile Size in Inches	No. of Nails or Staples per Tile	Approximate No. of Staples per 1,000 Sq. Ft.	Approximate Lbs. of Nails per 1,000 Sq. Ft.
12x12	4	4,000	6.0
12x24	6	3,000	4.5
16x16	4	2,250	3.4
16x32	6	1,690	2.6

Labor Placing Fiber Tile When Nailed In Place.—The labor cost of handling and placing fiber tile will vary considerably with the size of the tile and the skill of the mechanic placing same, the amount of nailing necessary and the surface to which the tile is applied. A man will place more tile on a good solid backing than on furring strips.

To the quantities given in the following table it will be necessary to add for blocking and furring, where necessary.

Quantities and Labor Costs of Applying Fiber Tile to Walls and Ceilings Where Tile are Nailed in Place

Add for wood furring strips or other necessary backing.

Size of Tile in Inches	No. Sq. Ft. per Tile	No. Tile Req'd per 100 Sq. Ft.	No. Placed per 8-Hr. Day	No. Sq. Ft. per 8-Hr. Day	Carp. Hrs. 100 Sq. Ft.
12x12*	1.0	100	180—200	180—200	4.2
12x24*	2.0	50	95—105	190—210	4.0
16x16*	1.78	56¼	120—130	215—235	3.6
16x32*	3.56	28¼	83— 90	295—315	2.7

*Stock sizes.

Applying Insulating Tile Using Adhesives.—Special adhesives known as Adhestik, Stickum, Armstrong's Brush-on Ceiling Cement, Celotex Adhesive, etc., are available for applying fiber tile.

Apply the adhesive in spots or dabs about 2″ in diameter, ¼″ to ⅜″ thick, one on each corner of the square tileboard and two or more additional spots on the rectangular sizes. Keep adhesive about 1″ from edges of fiberboard units and use approximately 4 spots per sq. ft. Adhesive spots should not be spaced over 10″ on centers in any direction.

After dabs of adhesive have been applied, place the tile in its final position. Slide back and forth for a distance of about ¾ inch under uniform pressure of the hands to obtain good contact. When working units larger than 16″x16″, two men should exert pressure simultaneously for best results. If the surface of the unit is below the level of adjoining pieces, do not pull the unit away from the base to bring surface level but remove it and add more adhesive. Again work into position as described above to obtain correct surface level.

Brad or shore the first units on either walls or ceilings to prevent sliding out of position during application of surrounding units. Do not bend units over high spots.

Tile and plank may be applied to plasterboard, sound plaster, plywood or lumber. In each case the use of adhesive or a combination of adhesive and brads is recommended.

Coverage Chart of Adhesive

Size of Tile in Inches	No. Spots per Tile	Sq. Ft. Per Gal.	Gals. per 1,000 Sq. Ft.
12x12	4	40	13
12x24	6	40	13
16x16	4	60	10
16x32	6	60	10

Price, $3.50 per gal.

Labor Placing Fiber Tile Using Adhesive.—The labor cost of placing fiber tile using adhesive or adhesive and nails will vary greatly with the skill and experience of the workman applying same, size of tile, etc. For instance, where an experienced man is placing the tile, and has a helper to build scaffold, unpack tile and apply the adhesive to the backs of the tile and the mechanic merely slides them in place, an experienced mechanic and helper should place 40 to 45 sq. ft. of 12x12-in. tile an hour but if one man is working alone and he must stop to apply the adhesive to each tile, set it in place and then drive several brads through them, 15 to 20 sq. ft. an hour would probably be the average. For this reason, conditions under which the tile are to be installed must be carefully considered before arriving at the labor cost.

The design in which the tile are laid also affects the labor costs. For instance when tile are laid in herringbone pattern, it requires about 30 to 40 percent more time than regular square or common bond. Diagonal patterns require about 20 to 25 percent more time than regular squares or common bond while tile laid in mixed ashlar designs require about 50 percent more time than straight squares or common bond.

The quantities and costs given in the following table are based on using two men consisting of an experienced mechanic to place the tile and one man to build scaffold, unpack the tile and place them on the scaffold and to place the adhesive on the back of the tile ready for the mechanic.

If the work is performed by inexperienced men, the labor costs as given, may be doubled.

Quantities and Labor Costs of Applying Fiber Wall Tile to Walls and Ceilings Using Adhesive and Nails Where Necessary

Add for cleaning plaster or other work necessary for applying tile.

The quantities and costs given in the following table are based on using a 4 or 5-ft. scaffold consisting of horses and planks and laying the tile in plain squares or common bond.

Size of Tile in Inches	No. Sq. Ft. per Tile	No. Tile Req'd per 100 Sq. Ft.	No. Placed per 8-Hr. Day	No. Sq. Ft. per 8-Hr. Day	Hrs. per 100 Sq. Ft.
12x12*	1.0	100	165—185	165—185	4.5
12x24*	2.0	50	88 - 98	175—195	4.4
16x16*	1.78	56¼	112—125	200—220	3.9
16x32*	3.56	28¼	65— 70	230—250	3.3

*Standard sizes.

If tile are laid in herringbone pattern, add 30 to 40 percent to the above labor costs; if laid in diagonal patterns, increase the above labor costs 20 to 25 percent, and if laid in mixed ashlar designs, add about 50 percent to the above labor costs.

When placing tile in auditoriums and other spaces requiring high scaffolding, add cost of scaffolding.

Large jobs are applied faster proportionately than small jobs.

Presdwood, Hardboard, Panelboard, Temwood

There are a number of makes of board made of wood fiber and pressed into board form under flat bed hydraulic presses that are much thinner and possess much greater strength than ordinary wallboard and are used for both interior and exterior work.

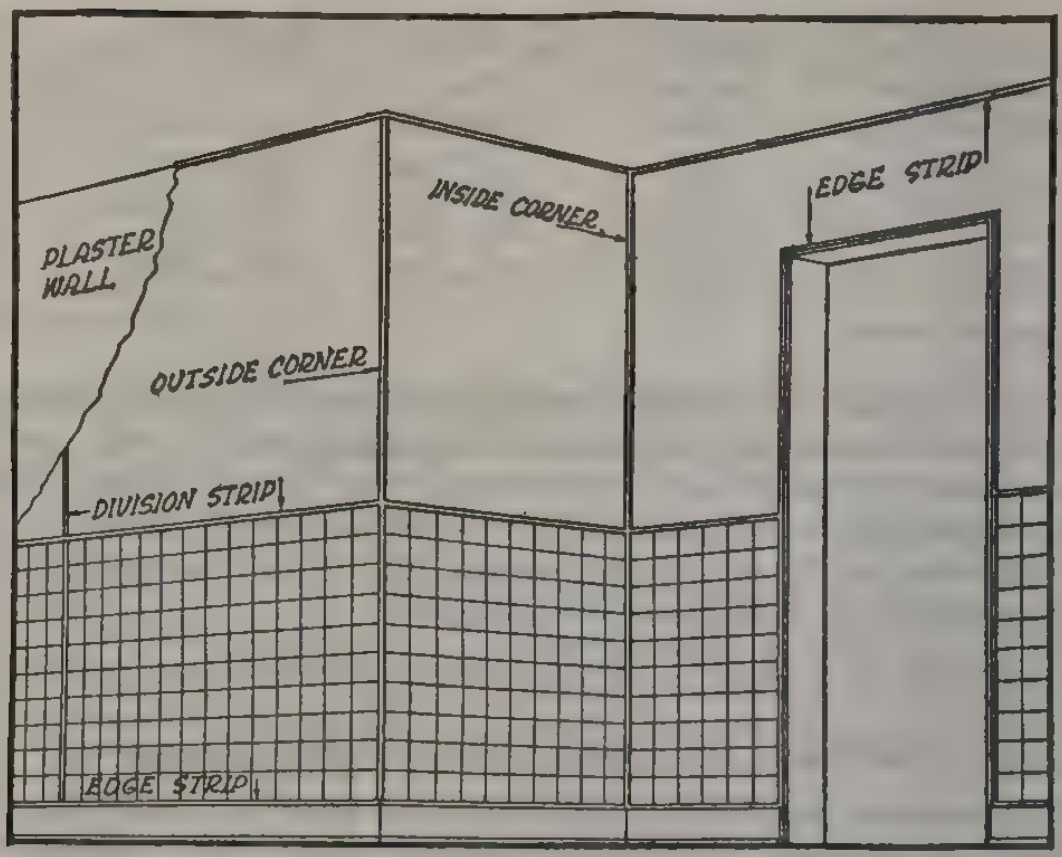
These hardboards are used for interior finish of walls and ceilings, cupboards, lining of closets, clothes chutes and similar purposes.

They are usually furnished ⅛", $\frac{3}{16}$", ¼" and $\frac{5}{16}$" thick, 4 ft. wide and 4 to 12 ft. long, although they vary somewhat among different manufacturers.

Tempered hardboard, Temwood or Presdwood are the same materials as described above, except they have been subjected to a tempering treatment which further increase the strength, resistance to abrasion, durability and ease of painting. Tempered hardboards, ¼" and $\frac{5}{16}$" thick are used for the exterior of homes and other small buildings. It is also used quite extensively for concrete form work.

These hardboards or tempered boards are in no way comparable with ordinary wallboard, as it is a far more dense material, having greater tensile and transverse strength, greater resistance to abrasion, lower moisture absorption, and when properly applied, no warping or buckling.

The labor cost of placing hardboard will run approximately the same as placing other types of board under the same conditions.



Method of Placing Tileboard in Bathrooms, Kitchens, etc.

Approximate Square Foot Prices of Temwood, Presdwood, Hardboard, Panelboard, Etc.

Thickness of Hardboard in Inches			
1/8"	3/16"	1/4"	5/16"
$0.11	$0.13	$0.15	$0.19
Tempered Temwood and Tempered Presdwood:			
$0.14	$0.16	$0.18	$0.21

Presdwood Temprtile

Presdwood Temprtile has score lines impressed in one surface forming 4"x4" squares. The board is denser than Tempered Presdwood and has a lower rate of water absorption.

This material is used for walls in bathrooms, kitchens, lavatories, restaurants, barber shops and similar places. It is furnished in sheets 4'-0" wide and 2'-0" to 12'-0" long.

Tempered board or tileboard should be cemented to the walls, using Armstrong's Panelboard Cement or a cement of equal quality. The adhesive should be applied to the back of the boards with a saw-tooth trowel, the boards having first been cut to fit. Use supplementary nailing or shoring to hold the boards firmly until the adhesive takes a partial set. Where it is neces-

sary to nail the board to the walls, small brads should be used where scored lines intersect.

Figure about 1 gal. waterproof cement per 50 sq. ft. of wall.

Presdwood Temprtile $\frac{1}{8}$" thick costs about 20 cts. per sq. ft. unpainted.

Prefinished Tileboard.—Tileboard $\frac{5}{32}$" thick, made of Masonite tempered Presdwood, is furnished scored 4"x4" to represent tile and finished with multiple coats of enamel or lacquer. Tileboard is also furnished without scoring, if desired.

These boards are furnished with dull or "velvet" finish or with a high gloss finish in a variety of colors with contrasting joints.

Tileboard is furnished in sheets 4 ft. wide and 4, 5, 6, 7, 8, 9, 10 and 12 ft. long.

Tileboard having a semi-gloss or high gloss finish costs about 45 cts. per sq. ft. depending upon size of board.

Cap molding $1\frac{3}{4}$-in. wide for use at the top of the wainscoting is furnished in strips 4 and 8-ft. long, scored to match tile or unscored, costs 30 cts. per lin. ft.

Base molding $3\frac{3}{4}$-in. high, scored or unscored, in colors to match tileboard costs 36 cts. per lin. ft. Add 20% if molding is color matched to tile.

Placing Tempered Tileboard.—Where tempered tileboard is used in kitchens, for sink splashboards, bathrooms, shower stalls, and other small places, there is usually considerable cutting and fitting required to place a comparatively small square footage of board.

The safest method of estimating is to lay out each wall, showing number and sizes of pieces required, as it will cost almost as much to place a small panel as a large one.

Where the tileboard is secured by nails (without the use of adhesive), figure $\frac{3}{4}$-hr. to 1-hr. to fit and place each panel. Taking an average of 12 to 16 sq. ft. per panel, this will equal 125 to 150 sq. ft. per 8-hr. day.

However, if the tileboard is applied to walls, using an adhesive, a man should fit and place one panel in 1 to $1\frac{1}{4}$-hrs. or 100 to 125 sq. ft. per 8-hr. day.

This applies to both plain and prefinished tileboard.

One gallon of adhesive will cover about 100 sq. ft. of surface if "spot" glued or about 65 sq. ft. of surface if "spread' glued.

Price per gallon.....$3.75

Cost of 100 Sq. Ft. Tempered Tileboard, Secured to Walls With Nails

	Hours	Rate	Total	Rate	Total
105 sq. ft. tileboard.....		$.....	$.....	$0.45	$47.25
1-lb. brads		.....	.....	.50	.50
Carpenter	6	.....	.....	6.75	40.50
Cost per 100 sq. ft.....	6		$.....		$88.25
Cost per sq. ft.					.88

Cost of 100 Sq. Ft. Tempered Tileboard, Secured to Walls Using Adhesive

	Hours	Rate	Total	Rate	Total
105 sq. ft. tileboard.....		$.....	$.....	$0.45	$47.25
1.5 gal. adhesive.....		.....	.....	3.75	5.63
Carpenter	8	.....	.....	6.75	54.00
Cost per 100 sq. ft.....	8		$.....		$106.88
Cost per sq. ft.....					1.07

J-M Asbestos Flexboard.*—Flexboard is made of asbestos and cement, hydraulically re-pressed to give it unusual strength and flexibility. It is a stone gray color with a smooth, hard surface that needs no other finish for either outdoor or indoor use. It is fire-proof, moisture-proof and rot-proof.

It can be nailed within ⅜" of the edge without pre-drilling.

The 3/16" thickness Flexboard may be nailed directly to studding or joists spaced not more than 16" on centers. The ⅛" thickness should be nailed to a solid backing of ⅜" plywood or wood sheathing. It may also be applied with Flexboard cement supplemented with mechanical fasteners. May be curved up to 30" radius lengthwise and up to 36" radius crosswise for ⅛" thickness; up to 36" radius lengthwise and up to 54" radius crosswise for 3/16" thickness.

Standard Flexboard is furnished in 4'-0"x8'-0" sheets, in ⅛", 3/16" and ¼" thickness.

Approximate prices on J-M Asbestos Flexboard are as follows: ⅛" thick, 16 cts. per sq. ft.; 3/16" thick, 22 cts. per sq. ft. and ¼" thick, 19 cts. per sq. ft.

Figure installation costs about 25 percent more than given for Tempered Tileboard under similar conditions.

Transite* Flat Asbestos Sheets and Asbestos Wallboard.—An all-purpose building sheet composed of asbestos fiber and portland cement united under great pressure into dense monolithic sheets of great strength. It is suitable for both exterior and interior work, being impervious to all weather conditions as well as being fireproof, and is light gray in color.

*Johns-Manville Sales Corp.

Transite is furnished in sheets 36"x48", 42"x48", 42"x96", 48"x48" and 48"x96", ¼" to 2" thick.

Thickness, Weights and Prices of Flat Transite* Sheets

(Uncut Sheets)

Thickness Inches	Approximate weights in lb. per sq. ft. Uncrated	Crated	List Prices per Sq. Ft.
¼	2.7	3.1	$0.38
⅜	4.0	4.6	.45
½	5.2	6.0	.65
⅝	6.5	7.6	.85
¾	7.8	9.1	.95
1	10.3	12.3	1.30
1¼	12.2	14.2	1.70
1½	14.6	18.0	2.00

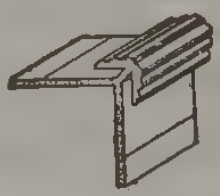
Wainscot Trim for Wallboard and Wall Tile

Moldings made of stainless steel, polished finish, in plain designs similar to illustrations. Punched for nails. Furnished in 4'-0", 6'-0" and 8'-0" lengths.

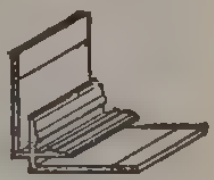
Description	For Wallboard	Per Ft.	Description	For Wallboard	Per Ft.
Cap Mold	⅛" thick	$0.16	Outside Corner	⅛" thick	$0.23
Joint Mold	⅛" thick	.25	Inside Corner	⅛" thick	.23
Tub edging or cove base				⅛" thick	.23

Cap Mold

Joint Mold



Outside Corner



Inside Corner

Metal covered wood cap, base or trim, size $\frac{5}{16}$" x 1½", chrome zinc, polished finish. Price per lin. ft. $0.30

Labor Placing Metal Moldings.—The labor cost of placing metal moldings will vary with the design and size of the panels, cutting and fitting necessary, etc., but on the average job, a carpenter should place 100 to 150 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	6	$.....	$.....	$6.75	$40.50
Cost per lin. ft.					.41

Items to Include When Making Up Wallboard Estimates.—When making up estimates on wallboard construction the

*Johns-Manville Sales Corp.

following items should be included to insure a complete and dependable estimate:

1. "Headers" or nailing strips to receive wallboard.
2. Furring strips on walls and ceilings where necessary.
3. Wallboard and labor placing same.
4. Wood or metal panel strips and labor placing same.
5. Labor filling nail holes with wood putty or crevice filler.
6. Beam ceilings, ceiling cornices, metal moldings, etc.
7. Painting and decorating wallboard and panel strips.
8. Nails and adhesive.
9. Overhead expense and profit.

PLYWOOD WALLBOARD

Plywood consists of an odd number of thin sheets or veneers of Douglas fir, consisting of 3, 5, 7 or 9 standard thicknesses—these being laminated with alternating grain direction. Because the grain of each ply composing the material is at right angles to the grain of adjacent plies, the strength of Douglas fir plywood panels is approximately equal in both directions.

All Douglas fir plywood from Association mills is made to conform to the moisture-resistance requirements set forth in the revised standards established by the National Bureau of Standards, as U. S. Commercial Standards CS45-55.

Plywall wallboard is the grade of plywood commonly used for interior walls and ceilings instead of lath and plaster or other types of wallboard. It is furnished in sheets 24 to 48-in. wide and 5 to 12 ft. long.

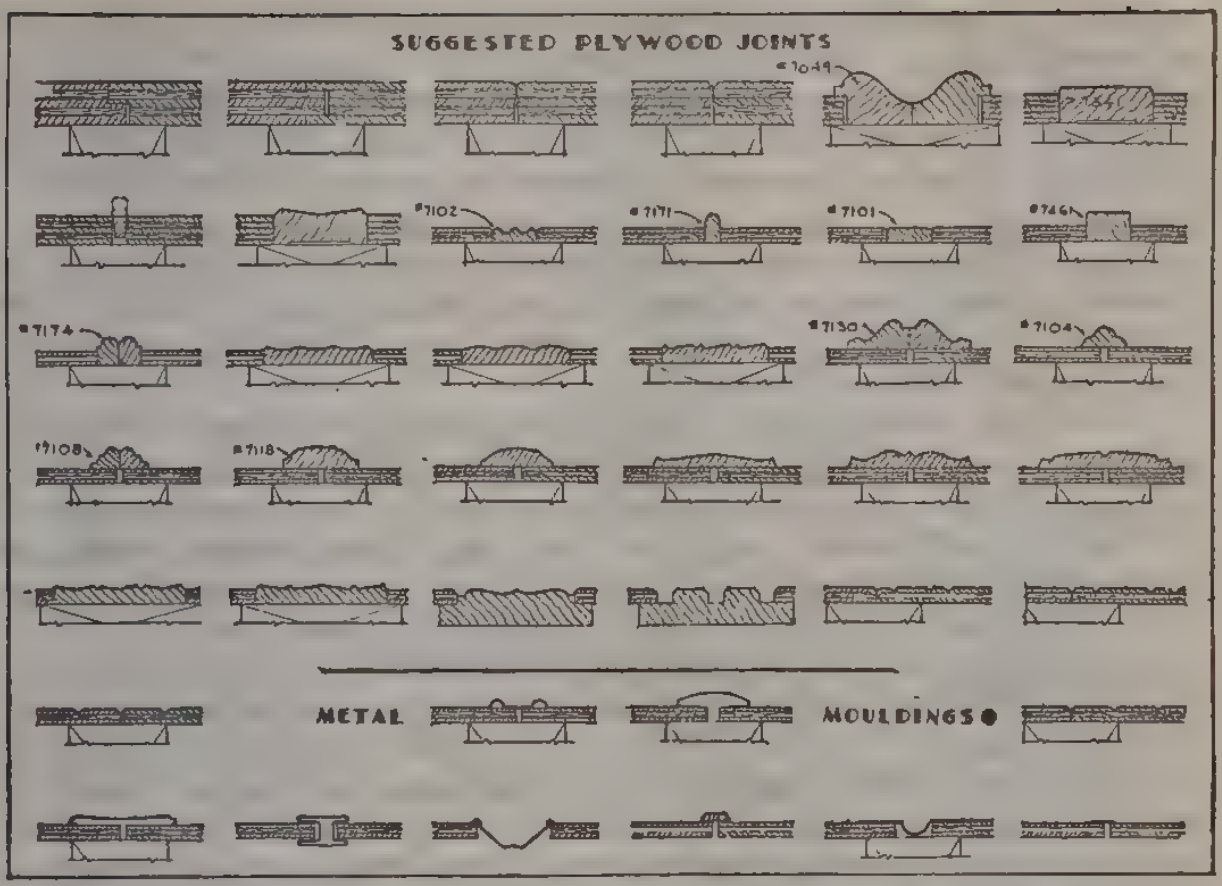
Plywall wallboard is furnished $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1 and $1\frac{1}{8}$-in. thick. The $\frac{1}{4}$-in. thickness is most widely used for walls and ceilings, although for more substantial construction $\frac{3}{8}$ or $\frac{1}{2}$-in. thick is often preferred. Thicker material is used for shelving, wardrobes, cases, etc.

Practically any design may be obtained by the use of plywood as with other types of wallboard. Four penny casing or finishing nails are recommended for paneling up to $\frac{1}{2}$-in. thick with the nails spaced 6 to 10 in. apart. One horizontal or fire stop should be cut in between top and bottom plates as a nailing piece.

Plywood panels may be finished by staining, painting, wall papering or mechanical surfacing.

Labor Applying Plywood Wallboard.—The labor cost of applying plywood wallboard will run about the same as given for fiber wallboard covering the same class of work.

Where special jointing of the panels is required to work out wall and ceiling panels, allow extra for grooving, beveling and any other designs worked into the wallboard.



Types of Joints Used with Plywood Wallboard.

Also add extra for applying panel strips as given on previous pages.

Prices of Douglas Fir Plywood

Made with water resisting glue. All panels sanded 2 sides to net thickness shown.

Size of Panel	Inches Thick	Number of Plies	Price per 1,000 Sq. Ft. Good 1 Side (A-D)	Good 2 Sides (A-A)
24″x60″ to 48″x96″	¼	3	$130.00	$170.00
24″x60″ to 48″x96″	⅜	3	160.00	200.00
24″x60″ to 48″x96″	½	5	200.00	240.00
24″x60″ to 48″x96″	⅝	5	230.00	270.00
24″x60″ to 48″x96″	¾	5	260.00	300.00

Hardwood Plywood Panels

During recent years hardwood plywood panels are being increasingly used for the interior walls of modern buildings.

These plywood panels of birch, oak, mahogany, etc., are usually furnished in sheets 4′-0″ wide and 8′-0″ to 10′-0″ high and are used instead of plaster or other wall finishes.

When using ¼″ plywood panels in large sizes for this class of

work it is necessary to have a substantial backing for the thin plywood panels. This may be obtained by applying the plywood direct to a brown or finish plaster coat wall; a ½" gypsum board backing, or better still, a ½" thick plywood backing with the sheets running in the opposite direction to that of the finish plywood panels.

These plywood panels are usually applied with the panel running from floor to ceiling in one length, i.e., 4'-0"x8'-0" or 4'-0"x10'-0", with the vertical joints butted flush or having a very slight bevel at the edges.

To obtain a first class job it is usually necessary to apply adhesive to the back of the plywood panels and also use small brads to secure the plywood in place until the adhesive sets.

This is particular work as the adjoining sheets must be accurately fitted together if a first class job is to result.

If wood panel strips are to be used to conceal the joints, it is not necessary to use so much care in placing the panels.

Labor Placing Flush Plywood Wall Panels.—When applying plywood panels 4'-0"x8'-0" to 4'-0"x10'-0", with the abutting joints fitted tightly together, using adhesive and small brads to secure the plywood to the backing, two carpenters working together should handle, fit and place one plywood panel in 1½ to 2 hours, or they should place 4 to 5 panels per 8-hr. day.

Many of the panels will have to be cut to half or three-quarter size, and in some instances cut out for doors and windows, so a certain length of time should be allowed for each piece of plywood, rather than figuring on a square foot basis.

Labor Placing Plywood Wall Panels Using Strips to Conceal the Joints.—If the plywood panels are applied to the walls and the joints concealed by the use of panel strips, figure on the same basis as given on the previous pages for "Wall Board" applied under similar conditions.

Sq. Ft. Prices of Hardwood Laminated Veneer Panels

Made of selected veneers, carefully matched and glued. All sanded 2 sides to net thickness shown. All prices are quoted on the basis of 1,000 sq. ft., grade A-2 for ¾" thickness, A-3 for others.

BIRCH, PLAIN, ROTARY CUT

Size of Panel	¼" Thick–3-Ply	⅜" Thick–5-Ply
36"x72" to 48"x72"	$0.30	$0.50
36"x84" to 48"x84"	.32	.55
36"x96" to 48"x96"	.34	.60
Size of Panel	**½" Thick–5-Ply**	**¾" Thick–5-Ply**
36"x72" to 48"x72"	$0.55	$0.70
36"x84" to 48"x84"	.57	.73
36"x96" to 48"x96"	.60	.75

MAPLE, WHITE, ROTARY CUT

Size of Panel	¼" Thick—3-Ply	⅜" Thick—5-Ply
36"x72" to 48"x72"	$0.38	$0.85
36"x84" to 48"x84"	.40	.88
36"x96" to 48"x96"	.45	.90

OAK, RED, PLAIN SLICED

Size of Panel	¼" Thick—3-Ply	⅜" Thick—5-Ply
36"x72" to 48"x72"	$0.42	$0.83
36"x84" to 48"x84"	.45	.89
36"x96" to 48"x96"	.50	.91

OAK, WHITE, PLAIN SLICED

Size of Panel	¼" Thick—3-Ply	⅜" Thick—5-Ply
36"x72" to 48"x72"	$0.67	$0.88
36"x84" to 48"x84"	.70	1.00
36"x96" to 48"x96"	.73	1.05

OAK, WHITE, RIFT SAWED

Size of Panel	¼" Thick—3-Ply	⅜" Thick—5-Ply
36"x72" to 48"x72"	$0.74	$0.90
36"x84" to 48"x84"	.78	1.05
36"x96" to 48"x96"	.80	1.10

WALNUT, PLAIN SLICED

Size of Panel	¼" Thick—3-Ply	¾" Thick—5-Ply
36"x72" to 48"x72"	$0.75	$1.40
36"x84" to 48"x84"	.80	1.60
36"x96" to 48"x96"	.85	1.70

WALNUT, QUARTER SAWED

Size of Panel	¼" Thick—3-Ply	⅜" Thick—5-Ply
36"x72" to 48"x72"	$0.80	$1.60
36"x84" to 48"x84"	.90	1.70
36"x96" to 48"x96"	1.00	1.80

MAHOGANY, AFRICAN, RIBBON STRIPE

Size of Panel	¼" Thick—3-Ply	⅜" Thick—5-Ply
36"x72" to 48"x72"	$0.50	$1.40
36"x84" to 48"x84"	.60	1.45
36"x96" to 48"x96"	.65	1.50

Also available in Prima Vera, Avodire, Chen Chen, Blonde Limba, Korina and other light colored tropical woods.

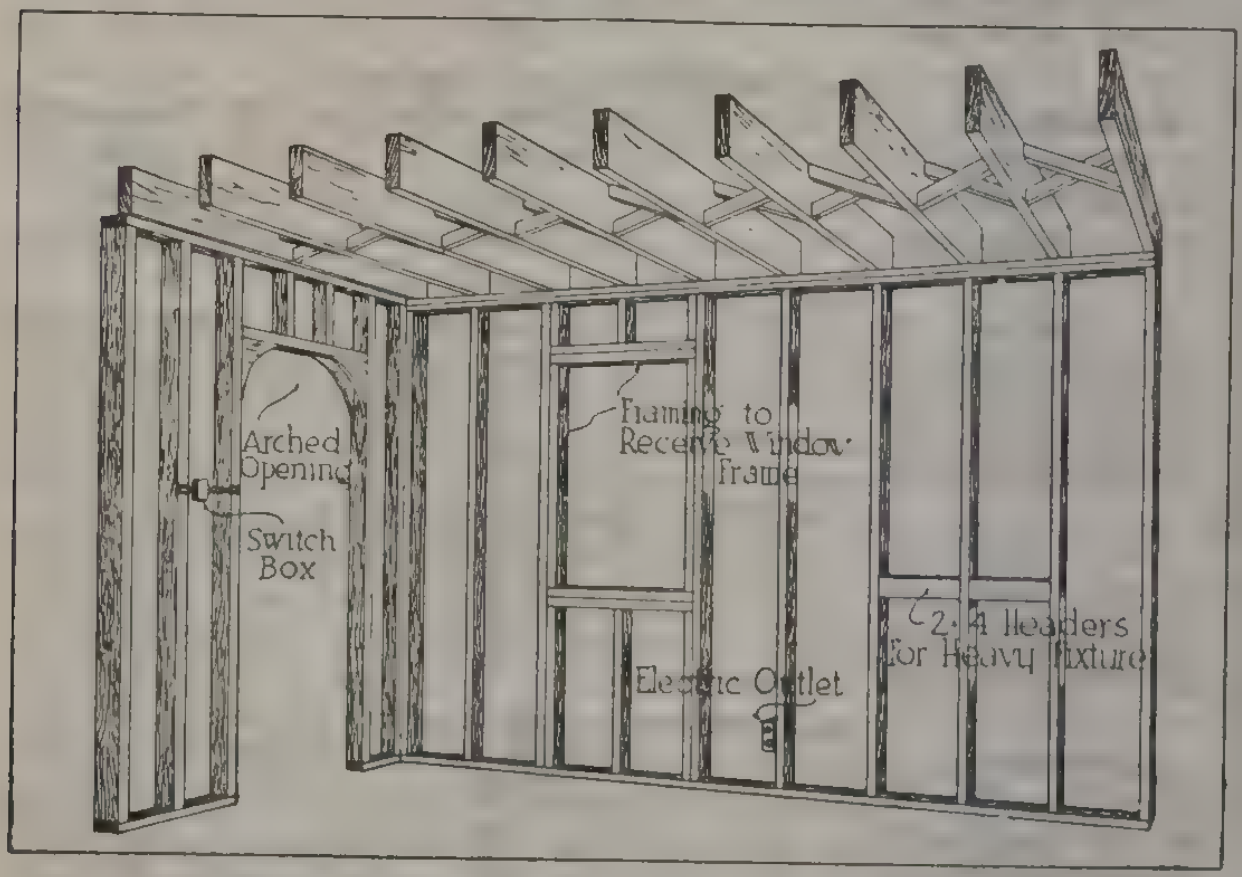
GYPSUM WALLBOARD

Gypsum wallboard is made of gypsum, molded while in a plastic condition between two sheets of tough protective paper. It is used for walls and ceilings in buildings of all types and takes all types of painting and decorating, including wallpaper.

Sizes and Thicknesses of Gypsum Wallboard

Thickness	Width	Length
¼-in.	48-in.	6 to 12 ft.
⅜-in.	48-in.	6 to 12 ft.
½-in.	48-in.	6 to 14 ft.
⅝-in.	48-in.	6 to 14 ft.

The ¼-in. thick wallboard is furnished with square edges, ⅜-in. thickness with square, beveled or tapered edges. The ½-in. thick-



Illustrating Proper Framing for Gypsum Wallboard

nesses are furnished with square or tapered edges. The ⅝-in. thickness is only furnished with tapered edges.

One-quarter inch gypsum wallboard is used as a lightweight, low cost, utility wallboard. It is also used for curved surfaces or to cover existing wall surfaces. Three-eighths inch gypsum wallboard is used principally for repair or remodeling work or in double wall construction. One-half inch gypsum wallboard is used in single layer new construction. Five-eighths Type "X" inch gypsum wallboard is used where a one-hour fire rating is required or where the framing is spaced in excess of ½-in. wallboard limitations.

Tapered edge gypsum wallboard is manufactured with a de-

pression on the surface of the board along the long edges so that when two pieces are placed together a channel is formed to receive the joint reinforcement, providing a smooth continuous surface.

Tapered edge gypsum wallboard joints reinforced with perforated tape and cement make a joint as strong as the board itself, permitting "horizontal construction"—that is, placing the board with the long edges at right angles to the framing and using no headers to back up the joints.

The following are nail recommendations with respect to size and spacings, courtesy of the Gypsum Association:

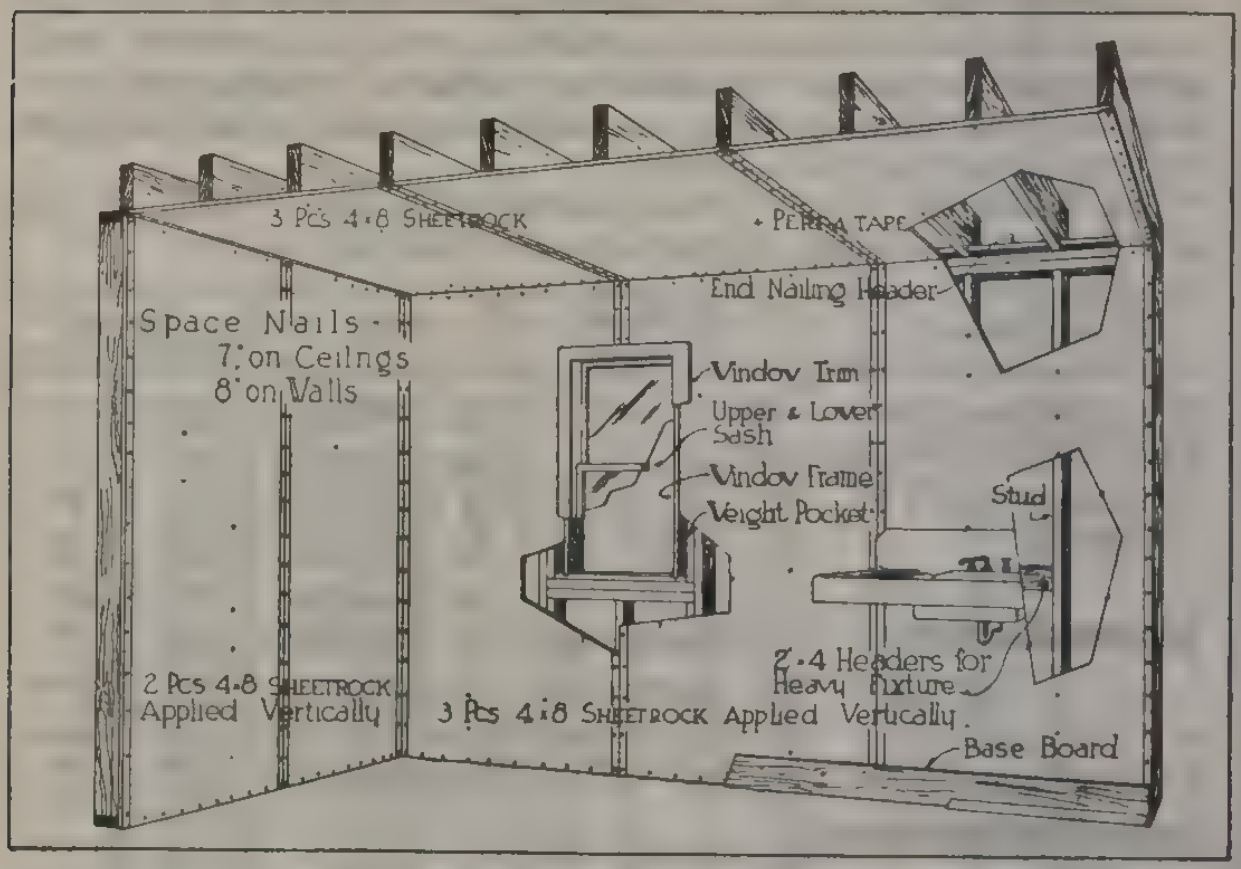
Nails	Wallboard Thickness	Nail	Spacing Walls	Spacing Ceilings
GWB-54 Annular Ring Nails—$\frac{1}{4}$" head—.098 gauge—ASTM C380-60T	$\frac{3}{8}$"	$1\frac{1}{4}$ GWB-54	8"	7"
	$\frac{1}{2}$"	$1\frac{3}{8}$ GWB-54	8"	7"
	$\frac{5}{8}$"	$1\frac{3}{8}$ GWB-54	8"	7"
	$\frac{1}{2}$" Type "X"	5d Cooler	7"	6"
$1\frac{1}{4}$" long	$\frac{5}{8}$" Type "X"	6d Cooler	7"	6"
	$\frac{3}{8}$" Backer Bd.	$1\frac{1}{4}$ GWB-54	8"	7"
$1\frac{3}{8}$" long	$\frac{1}{2}$" Backer Bd.	$1\frac{3}{8}$ GWB-54	8"	7"*
Cooler Type Nails	$\frac{1}{4}$"	1" penetration	8"	7"
4d—$1\frac{3}{8}$" long—$\frac{7}{32}$ head—14 ga.				
5d—$1\frac{5}{8}$" long—$\frac{15}{64}$ head—$13\frac{1}{2}$ ga.				
6d—$1\frac{7}{8}$" long—$\frac{1}{4}$ head—13 ga.	*5" on framing spaced 24" o.c.			

Approximate prices of gypsum wallboard are as follows: $\frac{1}{4}$-in. thick, $3\frac{1}{2}$ to 4 cts. per sq. ft.; $\frac{3}{8}$-in. thick, 5 cts. per sq. ft.; $\frac{1}{2}$-in. thick, 6 to $6\frac{1}{2}$ cts. per sq. ft.; $\frac{5}{8}$-in. thick, $7\frac{1}{2}$ to 8 cts. per sq. ft.

Perforated Tape Joint Systems for Gypsum Wallboard.—This method of concealing joints in gypsum wallboard is backed by over 20 years of joint reinforcing experience. It conceals the joints between boards and welds the gypsum wallboard units together into a single, smooth, even wall and ceiling surface unit.

It consists of a perforated fiber strip $2\frac{1}{16}$-in. wide, 250 ft. long, with sufficient compound included in the package for application of

the tape. Estimate about 1½ boxes or 375 lineal feet of tape per 1,000 sq. ft. of wallboard. It is also furnished in boxes containing 60 lin. ft. of tape, and sufficient compound to cover 150 sq. ft. of gypsum wallboard.



Vertical Application of Gypsum Wallboard

Price $3.80 per package containing compound and 250 lin. ft. of tape or approximately 1.5 cts. per lin. ft. of joint.

Method of Application of Perforated Tape Joint Systems.—This method of concealing joints is used with tapered edge gypsum wallboard.

First, the hollow or channel at the edges of the wallboard is filled with compound, using a 4" or 5" joint finishing broadknife.

Apply the perforated tape immediately, directly over the compound and press it into place with the broadknife, squeezing excess compound out from under the tape, but leaving enough compound under tape for proper bond.

Apply thin covering coat of compound immediately and let dry.

Next, apply another thin coating of compound so that the tape will be completely hidden. Feather out edges beyond previous coat as smoothly as possible and let dry thoroughly. Intermediate nail heads should also be carefully filled with compound and brought flush with the surface of the board.

Apply third and finish coat of compound, of thinner consistency to even up surface and edges of joint.

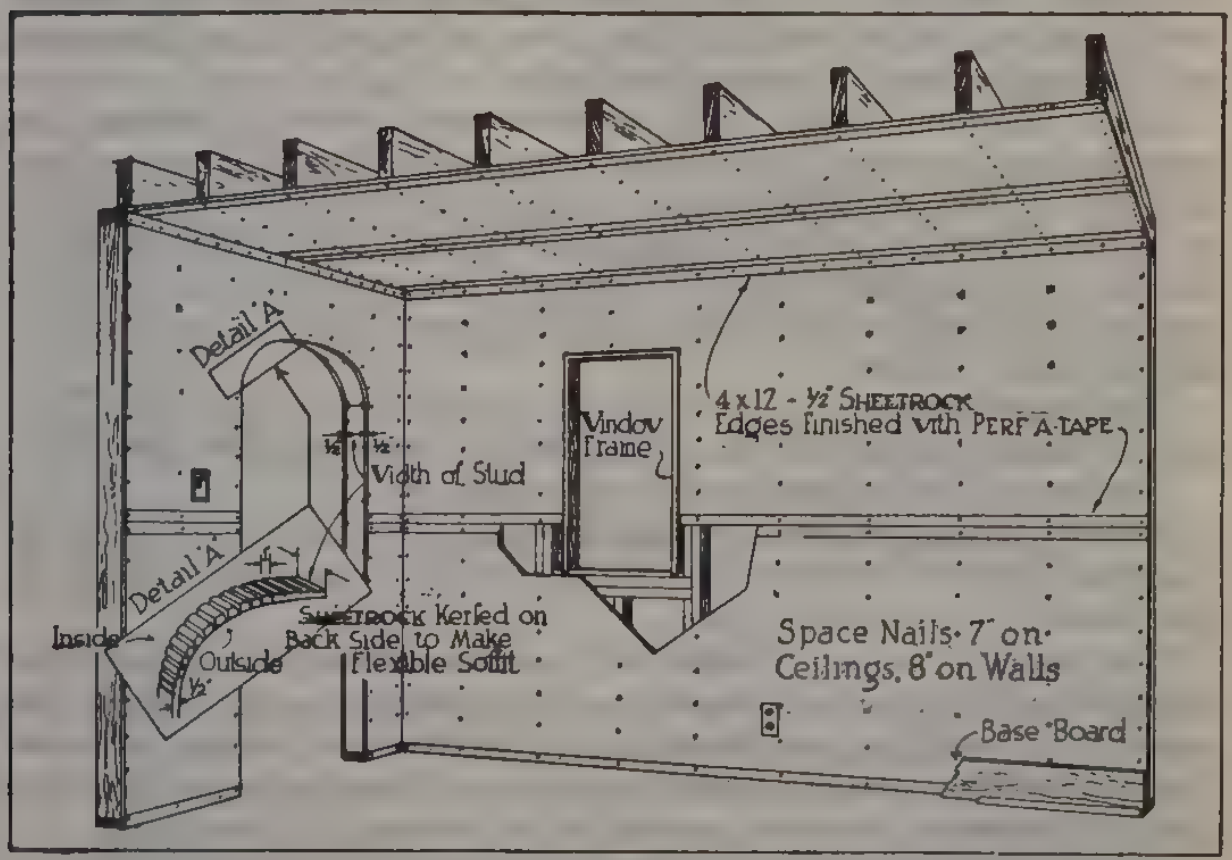
Sand, as necessary, between and after coats to insure smooth, inconspicuous joint.

Labor Placing Gypsum Wallboard.—When placing $\frac{3}{8}$" or $\frac{1}{2}$" gypsum wallboard in average size rooms, a carpenter experienced in wallboard erection should place 700 to 900 sq. ft. of board per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$.....	$.....	$6.75	$6.75
Cost per sq. ft.			.....		.07

When placing $\frac{3}{8}$" or $\frac{1}{2}$" gypsum wallboard in small rooms and spaces requiring considerable cutting and fitting in proportion to the number of square feet of board placed, a carpenter should place 350 to 450 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50
Cost per sq. ft.			.....		.14



Horizontal Application of Gypsum Wallboard

For $\frac{5}{8}$" gypsum wallboard, add 10 to 15 percent to above costs.

Labor Applying Perforated Tape Joint Systems.—On an aver-

age job, an experienced mechanic should apply and finish 200 to 225 lin. ft. of perforated reinforced joint system per 8-hr. day, or based on 1 lin. ft. of joint to each 3 sq. ft. of wall surface, an experienced carpenter or painter should finish 200 to 225 lin. ft. of joints (600 to 675 sq. ft. of wallboard) per 8-hr. day.

The cost of material and labor for 100 lin. ft. of perforated tape joints or 300 sq. ft. of wall, should cost as follows:

	Hours	Rate	Total	Rate	Total
100 lin. ft. tape inc. compound		$.....	$.....	$0.015	$ 1.50
Carpenter applying and finishing	3.8	.....	.....	6.75	25.65
Cost per 100 lin. ft. (300 sq. ft.) wall	3.8		$.....		$27.15
Cost per lin. ft. joint			.....		.27
Cost per sq. ft. wall			.....		.09

Applying Perforated Tape by Machine.—Most professional dry wall joint finishers use taping machines for applying perforated tape to joints. An average operator, using a taping machine, can apply tape up to 5 times faster than by ordinary hand methods, resulting in an overall labor time saving of 15 to 20 percent on the entire joint finishing operation.

Most popular models are manufactured from aluminum or magnesium, for light weight, and are designed to hold a standard 250-ft. roll of tape with enough compound capacity to permit application of entire roll with one or two fillings, depending upon the thickness of coating desired. Thumb screw control regulates the amount of cement pulled out with the tape. Approximate price, $25.00 f.o.b. factory.

Wallboard Filler.—A specially prepared setting type filler (cement) used to spot nail heads and repair deep surface abrasions.

Put up in 5 lb. boxes costing about 50 cts.

2-Ply Gypsum Wallboard Application.—In better class dry wall contruction, the 2-ply system of applying gypsum wallboard is the method most widely used.

No special framing is required, headers at horizontal joints are unnecessary and only the usual provisions for corner nailing are required. Two-ply gypsum wallboard is intended for use on building frames that comply with conventional standards and does not require premium framing materials or unusual workmanship.

To obtain the best results, the finish panel should be applied at right angles to the direction of the first panel, as cross lamination gives the greatest strength. Also, the use of the longest length panels the job will accommodate, particularly on the finish layer,

is recommended to reduce the end joints to a minimum, thereby reducing the amount of joint treatment required.

The first ply may be regular ⅜" gypsum wallboard or ⅜" thick 2'-0" x 8'-0" square edge gypsum backing board. If the backing board is used, it is applied at right angles to the framing members. Both types are applied with 1¼" long GWB-54 ring shank nails or 4d cooler type nails. Nail spacing should be 6" on center for ceilings and 8" on center for walls. Nails should be driven flush with the face of the board.

The second ply of gypsum wallboard is laminated to the first with the same compound used for joint treatment. The compound is applied to the back of the second ply using a toothed trowel with ¼" x ¼" notches 2" on center for spreading the adhesive in an irregular pattern to an even distribution. The panel is then set, immediately, and held in place until the compound has dried with temporary nailing or bracing. After adhesive has dried thoroughly, temporary nails may be set or braces may be removed and joints may be treated the same as for single ply gypsum wallboard surfaces.

Labor costs on 2-ply gypsum wallboard erection should be about double that of single ply application for the erection of panels only. Joint treatment remains the same as for single ply application.

Decorating Gypsum Wallboard.—Gypsum wallboard takes any decorative treatment—paints, papers and wall fabrics. Like any other surface it should receive a good size coat before decoration is applied. It is imperative to apply a good coat of sealer or varnish size if wall paper or wall fabrics are to be used to permit their easy removal later.

Wood Grained Gypsum Wallboard.—Wood grained gypsum wallboard is reproduction by engraving and printing processes of the graining and color of a genuine wood surface. It is made in various sizes and finishes by the different manufacturers as follows:

Finish	Thick	Width	Length
Knotty Pine	⅜-in.	48-in.	6 to 12 ft.
Mahogany	⅜-in.	48-in.	6 to 12 ft.
Walnut	⅜-in.	48-in.	6 to 12 ft.

Price $80.00 to $85.00 per 1,000 sq. ft. Matching colored nails are available for all finishes.

The method and cost of erection is similar to standard gypsum wallboard where used with moldings or wood panel strips.

Insulating Gypsum Wallboard.—Insulating gypsum wallboard is standard wallboard with a thin, smooth, bright sheet of aluminum foil mounted on the back side. Furnished in $\frac{3}{8}$", $\frac{1}{2}$" and $\frac{5}{8}$" thicknesses; 48-in. wide; 8, 9, 10, 12 and 14 ft. long.

The foil backed surface gives gypsum wallboard an insulation value greater than $\frac{1}{2}$-in. fiber insulation board and forms an excellent vapor seal. Board must always be applied with the foil surface against the framing and adjacent to an air space.

Costs about $1\frac{1}{2}$ cts. per sq. ft. more than standard gypsum wallboard of the same thickness.

Fire resistant gypsum wallboard is stocked in $\frac{1}{2}$" and $\frac{5}{8}$" thicknesses, plain or foil backed, in sheets 4' wide by 8, 9, 10, 12 or 14' lengths. This board runs about $\frac{1}{2}$ ct. more than plain board, 2 cts. more with foil backing.

Back-up gypsum wallboard is manufactured in $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{5}{8}$" thicknesses for use in two layer applications or as a base for acoustical tile. It costs about $\frac{3}{4}$ ct. less than ordinary board of the same thickness.

Panel Gypsum Wallboard.—16" wide, $\frac{3}{8}$" thick, round-edged panels available in 7, 8 and 10-ft. lengths. Panel gypsum wallboard is furnished in knotty pine and striated predecorated finishes or plain to receive decoration. Panels may be erected over sound, clean existing surfaces using regular taping joint compound as an adhesive or they may be applied vertically to studs spaced 16" on center using matching colored nails for the predecorated finishes or 4d cooler type nails for the plain panels.

For estimating purposes, figure about 75 lbs. of joint compound to apply 1,000 sq. ft. of panels.

Approximate prices, Plain, 6 cts. per sq. ft.; Knotty Pine, 10 cts. per sq. ft.; Striated, 16 cts. per sq. ft.

Wallboard Corner.—A metal bead with perforated tape or metal wings. Applied with joint compound to reinforce external angles.

Furnished in 7'-0" and 8'-0" lengths and packaged in tubes of 200 lin. ft. and 1,000 lin. ft. Approximate price, 7 cts. per lin. ft.

FLEXIBLE INSULATION AND DEADENING FELT

Materials for insulating roofs, ceilings, walls and for sound deadening between floors and walls are furnished in a number of different forms.

These flexible materials furnished in rolls consist of cotton, wood, glass or vegetable fiber and other materials placed between two sheets of heavy paper and are sewed together forming a flexible blanket that can be tucked in out of the way places where a rigid material cannot be used.

These materials are usually furnished in rolls and are ½", ¾", 1" and 2" thick.

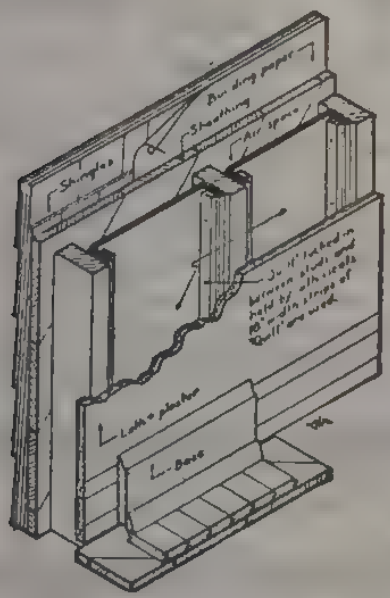
Placing Flexible Deadening Felt Under Finish Wood Floors.—Where roll insulation or deadening felt is placed over rough wood floors, a man should place 1,600 to 2,000 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.5	$.....	$.....	$6.75	$3.38
Cost per sq. ft.			.....		.34

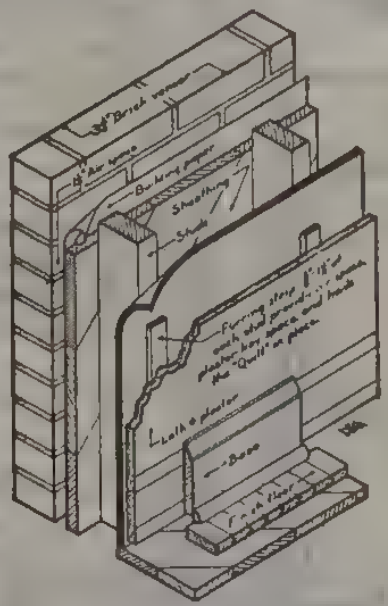
Placing Flexible Roll Insulation Over Sidewall Sheathing.—Where flexible insulation is placed over sidewall sheathing or nailed direct to studs, a carpenter should handle and place 800 to 1,000 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$.....	$.....	$6.75	$6.75
Cost per sq. ft.					.68

Placing Flexible Roll Insulation Between Studs.—When placing roll insulation between wood studs where lath are nailed



Flexible Insulation Placed Between Studs in Frame Construction.



Flexible Insulation Placed on Inside Face of Studs in Frame Construction.

to the sides of the studs to hold the insulation in place, a carpenter should handle and place 500 to 600 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$.....	$.....	$6.75	$10.125
Cost per sq. ft.					1.01

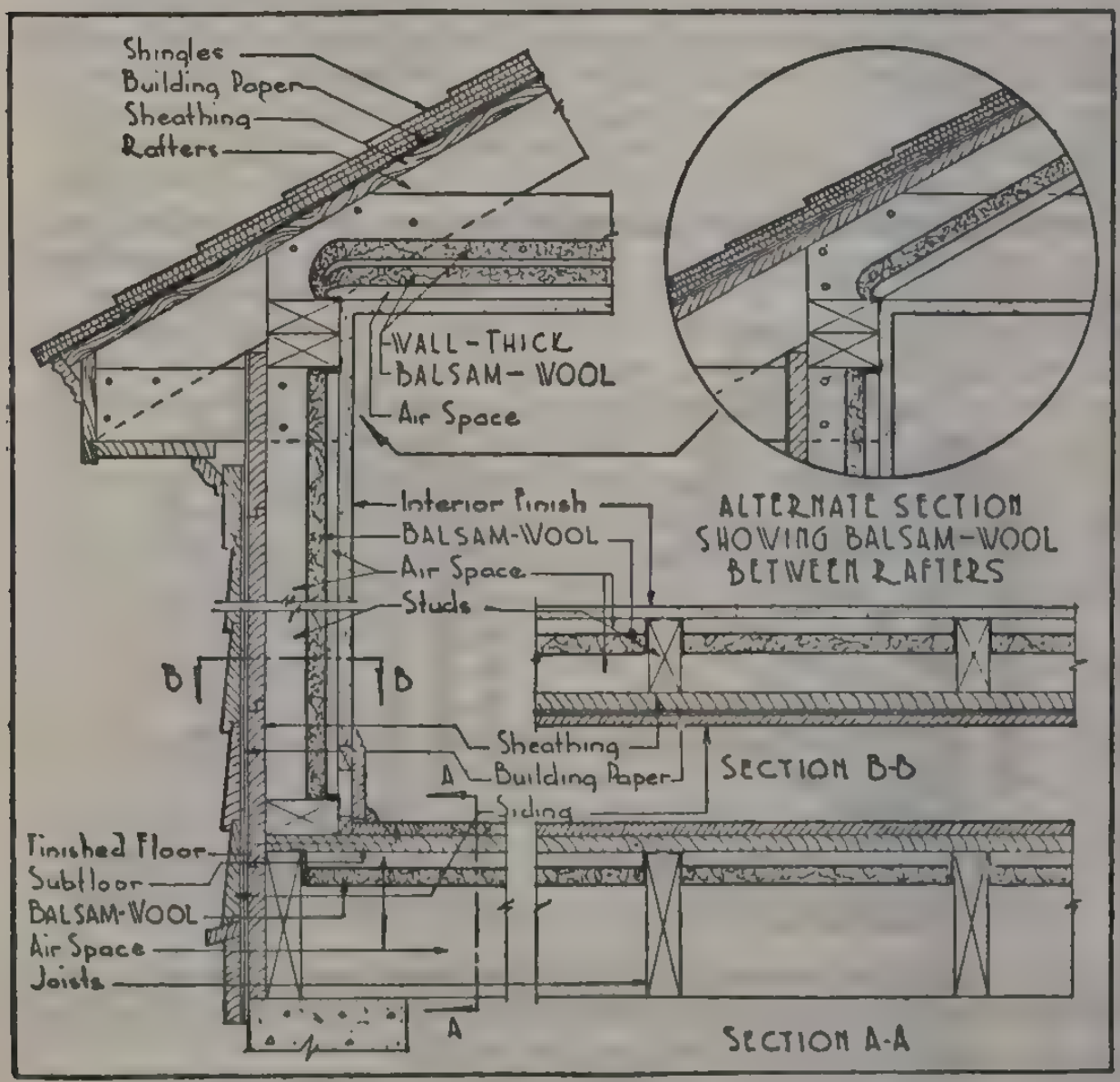
Cell-U-Blanket.—Cell-U-Blanket (Masonite) combines a semi-rigid insulating blanket of foamed fiber with a reflective in-

sulating surface to provide double thermal resistance. The blanket is encased in asphalt impregnated paper, providing a positive vapor barrier. A stiff flange insures accurate fitting, uniform air space, and easy staple fastening to studs and joints.

Cell-U-Blanket is manufactured approximately 1" thick in rolls 16", 20" and 24" wide containing 150 sq. ft. per roll. It is also made in 4'-0", 8'-0" and 8'-3" lengths.

Price, $60.00 per 1,000 sq. ft.

Balsam-Wool.—Balsam-Wool is a flexible type of insulation made from new wood fibers chemically treated to resist fire,



Methods of Using Balsam-Wool Flexible Insulation.

rot, termites and vermin. It is completely enclosed on both sides and edges with heavy, flexible, asphalt saturated and kraft liners.

The fibers of Balsam-Wool are waterproofed by a special treatment to make them non-absorptive. In addition, it is double sealed with a liner of tough, durable kraft, saturated and coated with asphalt to provide moisture protection and a vapor barrier. The new spacer flange is fastened to the face of the stud, rafter or joist with staple hammers and no lath are required.

Balsam-Wool is also used as a sound deadener because it has the ability to both absorb and reflect sound waves.

Balsam-Wool is furnished in the following thicknesses and widths:

Thickness	Widths	Approx. Price
1-in.	16, 20, 24 and 33 in.	$58.00 per 1,000 sq. ft.
2-in.	16, 20 and 24 in.	80.00 per 1,000 sq. ft.

Labor Placing Blanket Insulation with Spacer Flange.—Where blanket insulation having the spacer flange is applied between studs without the use of lath, a carpenter should place 900 to 1,100 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40
Cost per sq. ft.					.05

The labor cost of placing blanket insulation in rolls under floors, over side wall sheathing, etc., will be the same as given on the previous pages.

Kimsul.*—Kimsul building insulation is a thermal and acoustical blanket with a reflective surface made from wood fibers chemically treated to resist fire and moisture. It is not subject to attacks by insects and vermin.

Kimsul is packed in a compressed form (⅓ its installed volume) to facilitate handling and storing. Continuous stitching assures permanent application at the correct density of 1½ lbs. per cu. ft.

Kimsul is manufactured in a variety of widths and thicknesses to suit standard building construction needs, as follows:

Thickness	Width	Sq. Ft. per Roll	Price per 1,000 Sq. Ft.
Commercial ½-in.	16", 20", 24", 48"	200	$37.00
Standard 1-in.	16", 20", 24", 48"	200	52.00
Double Thick 2-in.	16", 20", 24", 48"	100	80.00

Labor Placing Kimsul Building Insulation.—Where Kimsul building insulation is used between studs, it is fastened at the top and bottom by using fiber strips furnished with each roll to secure it at the ends.

*Kimberly-Clark Corp., Chicago.

On work of this kind, a carpenter should handle and place 900 to 1,100 sq. ft. of Kimsul per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.8	$.....	$.....	$6.75	$5.40
Cost per sq. ft.			.....		.05

Where Kimsul is applied between joists, under roofs, etc., figure same labor costs as given on previous page for flexible insulation.

VAPOR SEAL PAPERS

The combination of high indoor relative humidities and low outside temperatures causes condensation to form within the structure. Serious damage can result from this moisture in the way of rotting framing members, paint deterioration, wet walls and ceilings, etc.

Vapor barriers are recommended where the above conditions exist.

Vapor seal paper should be installed on the warm side of wall, floor, ceiling, roof, etc. Paper should be installed with joints running parallel to and over framing members. All joints should be lapped about 2 inches. Where paper is to be exposed, nail wood lath strips over paper along framing members to provide a neat and permanent job.

A satisfactory vapor proof paper consists of a 50 lb. continuous asphalt film, faced on both sides with 30 lb. basis kraft paper. Other vapor proof papers consist of two 30 lb. basis sheets of kraft paper cemented together with asphalt and reinforced with strong jute cords, spaced ½ to 1-in. on centers and running in both directions. This same reinforced sheet is furnished with two sheets of asphalt coated paper cemented together and reinforced as described above. Another very satisfactory vapor proof paper consists of a heavy kraft paper coated on one side with a thin sheet of aluminum or copper, which prevents the penetration of moisture.

Approximate prices on the various types of vapor seal paper are as follows:

Description	Price per Roll 500 Sq. Ft.
2 sheets 30-lb. basis kraft paper cemented together with asphalt	$2.50
2 sheets asphalt coated 30-lb. kraft paper cemented together with asphalt and reinforced with jute cords	$5.50
1 sheet heavy kraft paper coated two sides with a reflective surface	$11.50

Sisalkraft.—A strong, waterproof, windproof building paper consisting of 2 sheets of pre-treated kraft paper cemented together with 2 layers of special asphalt and reinforced with 2 layers of crossed sisal fibers. Costs 1½ to 2 cts. per sq. ft.

Copper-Armored Sisalkraft is a combination of Sisalkraft and Anaconda electro-sheet copper bonded under heat and pressure. It is available in 3 weights, 1, 2 or 3 oz. copper per sq. ft.

It may be used for waterproofing, flashings, ridge roll flashing, etc. Approximate prices are as follows: 1-oz. costs 13 cts. per sq. ft.; 2-oz. costs 22 cts. per sq. ft. and 3 -oz. costs 32 cts. per sq. ft. Above prices subject to discount on large orders.

Sisalation reinforced reflective insulation acts both as a vapor-barrier insulation. Costs 2½ to 3 cts. per sq. ft.

Brownskin.—Creped kraft paper with layers of asphalt on both sides of the middle sheet. The two outside kraft sheets are infused with asphalt. Creped so that it will withstand the shocks of structural settling, shrinkage and extreme temperature changes. Prices approximately the same as given for Sisalkraft.

Copperskin.—A continuous layer of pure electro sheet copper bonded to brownskin paper. Furnished with 1-oz., 2-oz., and 3-oz. sheet copper. Price approximately the same as Copper-Armored Sisalkraft given above.

Polyethylene film comes in 100′ rolls of 2′, 3′, 4′, 6′, 8′, 10′, 12′, 14′, 16′ and 20′ widths in thickness of .004″ and costs $12.00 per 1,000 sq. ft. It also comes in 100′ rolls .006″ thick in 2′, 6′, 10′, 12′, 16′ and 20′ widths and costs $18 per 1,000 sq. ft. Polyethylene in .002″ thickness costs $6 per 1,000 sq. ft. but is not recommended as a permanent vapor barrier. Tape for sealing joints costs $3.25 for a roll 2″ wide by 100′ long in the .004″ thickness.

Labor Placing Vapor Seal Paper.—Where vapor seal paper is applied to the interior of exterior stud walls, using a stapling machine, to prevent the penetration of moisture and condensation, a carpenter should handle and place 2,000 to 2,500 sq. ft. per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.4	$.....	$.....	$6.75	$2.70
Cost per sq. ft.					.03

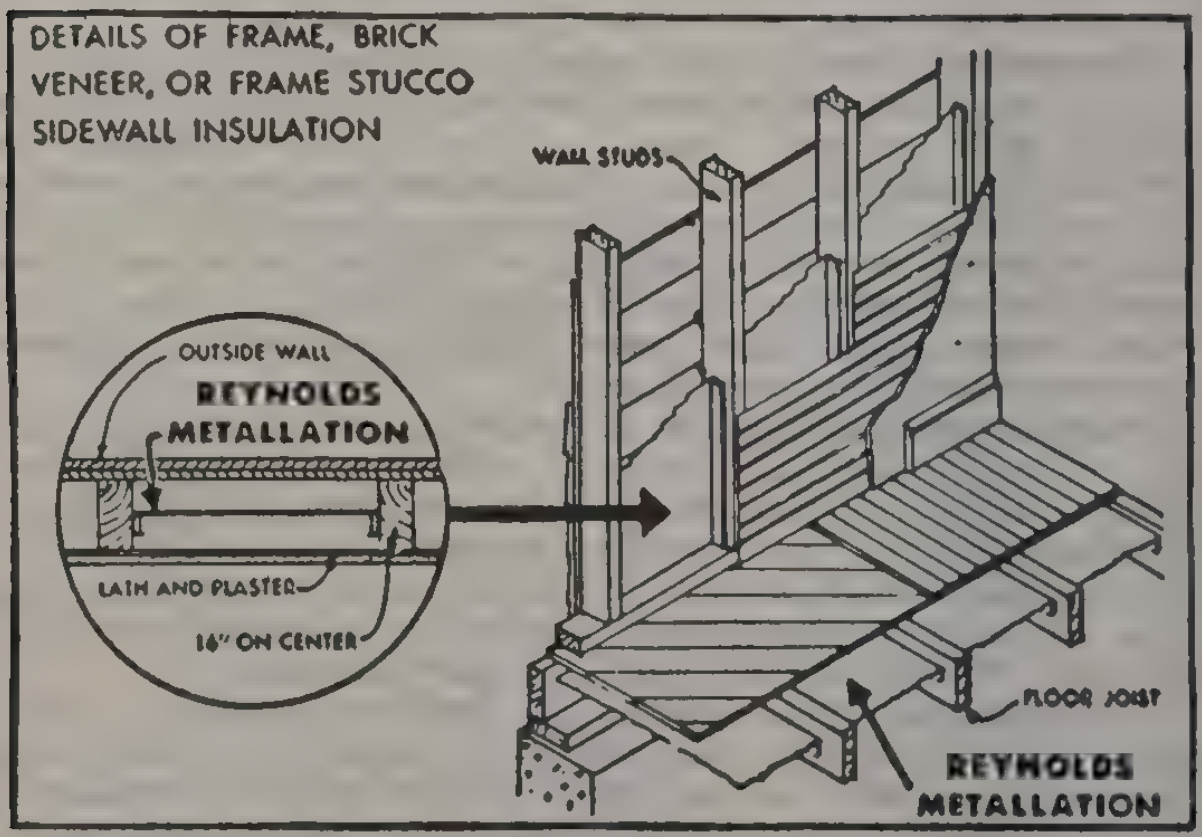
REFLECTIVE INSULATION

Since the principles involved in the use of aluminum foil or other bright metal sheet as thermal insulation may not be generally understood, a brief discussion will be given here.

Reflective materials, such as aluminum foil, derive their insulating properties from the fact they reflect radiant heat. Aluminum foil is used to increase the insulating value of air

spaces by reducing heat transfer by radiation. It is of value only in conjunction with air spaces and has no value in continuous contact with solid material on both sides, except insofar as it may act as a building paper in preventing air leakage.

Clean metallic surfaces in general are good reflectors and poor emitters of radiant heat. Visual brightness is not an essential index to good performance since aged and soiled aluminum surfaces are known to maintain reflectivities from 87 to 94 percent. The insulating effect does not depend upon the thickness of the metallic foil but the insulating value of air spaces bounded on



Method of Placing Aluminum Foil or Reflective Insulation Between Studs

one or both interior surfaces with aluminum foil increases with increasing width of space up to about ¾" width. Air spaces wider than about ¾" have substantially the same insulating value, regardless of width.

Reynolds Metallation Insulation.—Reynolds Metallation Insulation is a sheet of genuine aluminum foil cemented to one or both sides of heavy tough kraft paper, furnished in rolls. It can be used for insulating the walls and roofs of all types of buildings.

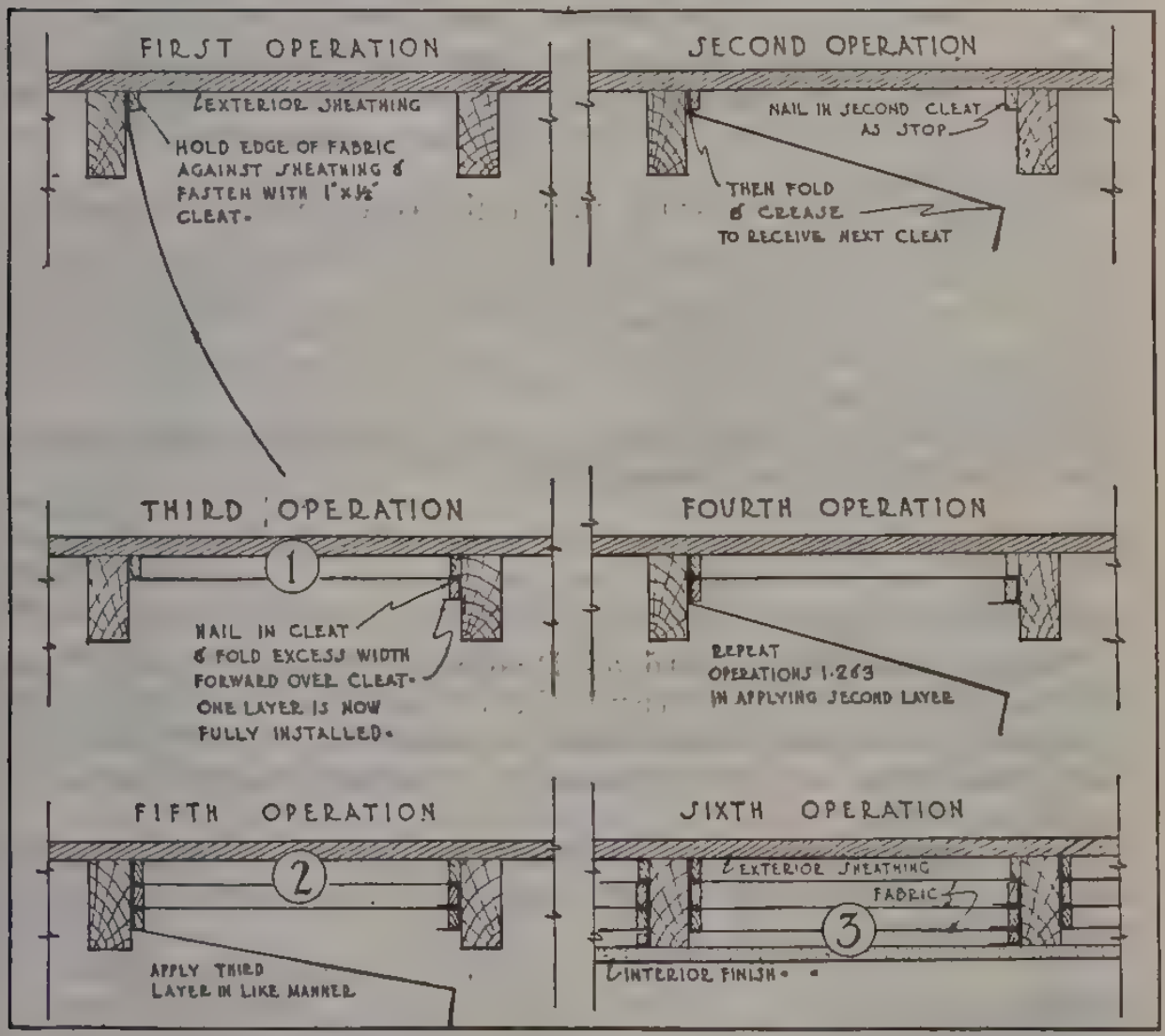
It is waterproof, windproof, verminproof, and non-absorptive,

therefore its insulating value is not affected by water or water vapor.

Reynolds Metallation Insulation is furnished in the following sizes:

Width	Length	Sq. Ft. per Roll	Weight
25	120 ft.	250	14 lbs.
33	90 ft. 4 in.	250	14 lbs.
36	83 ft. 4 in.	250	14 lbs.

Price, foil 1 side, 2 cts. per sq. ft.; foil 2 sides, 3 cts. per sq. ft.


FIRST OPERATION
EXTERIOR SHEATHING
HOLD EDGE OF FABRIC AGAINST SHEATHING & FASTEN WITH 1"x½" CLEAT.
SECOND OPERATION
NAIL IN SECOND CLEAT AS STOP
THEN FOLD & CREASE TO RECEIVE NEXT CLEAT
THIRD OPERATION
1
NAIL IN CLEAT & FOLD EXCESS WIDTH FORWARD OVER CLEAT. ONE LAYER IS NOW FULLY INSTALLED.
FOURTH OPERATION
REPEAT OPERATIONS 1-2&3 IN APPLYING SECOND LAYER
FIFTH OPERATION
2
APPLY THIRD LAYER IN LIKE MANNER
SIXTH OPERATION
EXTERIOR SHEATHING
FABRIC
3
INTERIOR FINISH

Method of Placing Sheet or Foil Insulation Between Studs Where Successive Layers Through Wall Section are Required.

Placing Sheet or Foil Insulation between Studs.—When placing sheet insulation between wood studs where lath or wood strips are nailed to the sides of the studs to hold the insulation in place, as illustrated above, a carpenter should place 500 to 600

sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$.....	$.....	$6.75	$10.125
Cost per sq. ft.			.....		.10

Where more than one thickness of insulation is placed between studs, figure each application of paper at the above labor costs.

INSULATING BUILDING BOARD

Description and Prices of Insulating Building Board.—There are a number of insulating and building boards on the market, some of them made of wood fiber, cane fiber, gypsum composition, etc., manufactured under slightly different methods and varying slightly in appearance but all used for the same general purpose and all selling at approximately the same price for similar materials.

These boards are marketed under the trade names of Temlok, Celotex, Beaver, Fir-Tex, Insulite, J-M Insulating Board, Gold Bond, Thermax, U.S.G. Insulating Board, Canec, Flintkote, Simpson, Nu-Wood, etc. Most of these insulating building boards are furnished 4'-0" wide, 6, 7, 8, 9, 10 and 12 feet long and ½-in., ¾-in. and 1-in. thick.

Practically all of the different brands of building board sell at approximately the following prices:

Thickness	Price per 1,000 Sq. Ft.
⅜-in. thick	$55.00-$80.00
½-in. thick	75.00- 90.00

Placing Insulating Board as Deadening Under Finish Wood Floors.—Rigid and semi rigid sheet insulation and deadening is usually furnished in sheets 48" wide and 6'-0" to 12'-0" long. The sheets must be "butted" when laid, but only occasional nailing is required.

When placing this type of deadening, a man should handle and place 1,200 to 1,400 sq. ft. per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.6	$.....	$.....	$6.75	$4.05
Cost per sq. ft.			.....		.04

Placing Insulating Board Under Ceiling Joists and Roof Rafters. Where the insulating boards are nailed to the underside of ceiling joists or roof rafters, the work proceeds much slower on account of the difficulty in handling the large sheets but a carpenter and laborer should place 800 to 1,000 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	0.9	$.....	$.....	$6.75	$6.08
Labor	0.9	.....	.....	5.00	4.50
Cost per 100 sq. ft.	1.8		$.....		$10.58
Cost per sq. ft.			.....		.11

BUILDING AND INSULATING SHEATHING

There are any number of insulating sheathing boards on the market, consisting of felted wood fiber or vegetable fiber products treated to make them moisture resistant.

Some of these sheets are coated with high melting point asphalt or are asphalt impregnated to form a moisture resistant surface which retards moisture penetration.

Insulating sheathing is furnished in sheets 4 ft. wide and 6, 7, 8, 9, 10 and 12 ft. long, and ½-in. and $\frac{25}{32}$-in. thick, the same thickness as wood sheathing.

Most manufacturers furnish this type of sheathing $\frac{25}{32}$-in. thick, 2 ft. wide and 8 ft. long, with the long edges V-jointed or shiplapped.

Insulating sheathing is usually applied to wood studs under wood siding, shingles, stucco or brick veneer and on account of the large size sheets used and the asphalt treatment, building paper is not ordinarily used with it, except under stucco.

Use 2 in. galvanized nails with ⅜ or ½-in. heads for insulating sheathing.

Place nails 3 inches apart on all outside edges of board and 6 inches apart for all intermediate nailing.

Insulating sheathing $\frac{25}{32}$-in. thick costs $120-$130 per 1,000 sq. ft.

Labor Placing Insulating Sheathing.—When placing insulating sheathing on square or rectangular houses of regular construction, a carpenter should place 700 to 900 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.0		$.....	$6.75	$6.75
Labor unloading and carrying sheets	0.3	.....	.....	5.00	1.50
Cost per 100 sq. ft.	1.3		$.....		$8.25
Cost per sq. ft.			.....		.83

On buildings of irregular construction, requiring a great deal of cutting and fitting, it is not possible to take advantage of the large size sheets as too much cutting and fitting is required. A carpenter will place only 350 to 450 sq. ft. of sheathing per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.0	$.....	$.....	$6.75	$13.50
Labor unloading and carrying sheets	0.3	.....	.....	5.00	1.50
Cost per 100 sq. ft.	2.3		$.....		$15.00
Cost per sq. ft.			.....		.15

Insulating Roof Decking

Several manufacturers produce insulating roof decking made of multiple layers of ½-in. insulating board laminated together with vapor resistant cement and fabricated into tongue and groove planks, 2'-0" wide, 8'-0" long and 1½", 2" or 3" thick, with a finish painted under surface. Provides a roof deck, insulation, vapor barrier and interior ceiling finish using only one material, and is especially adaptable for use in contemporary design ranch houses with exposed beam ceilings.

Insulating roof decking can be used for flat, pitched or monosloped roofs. Flat roofs and surfaces with a slope of 3" in 12" or less are usually covered with built-up roofing. Steeper roofs may be covered with rigid shingles, slate or tile roofing, providing wood nailing strips are fastened through decking to supporting beams below.

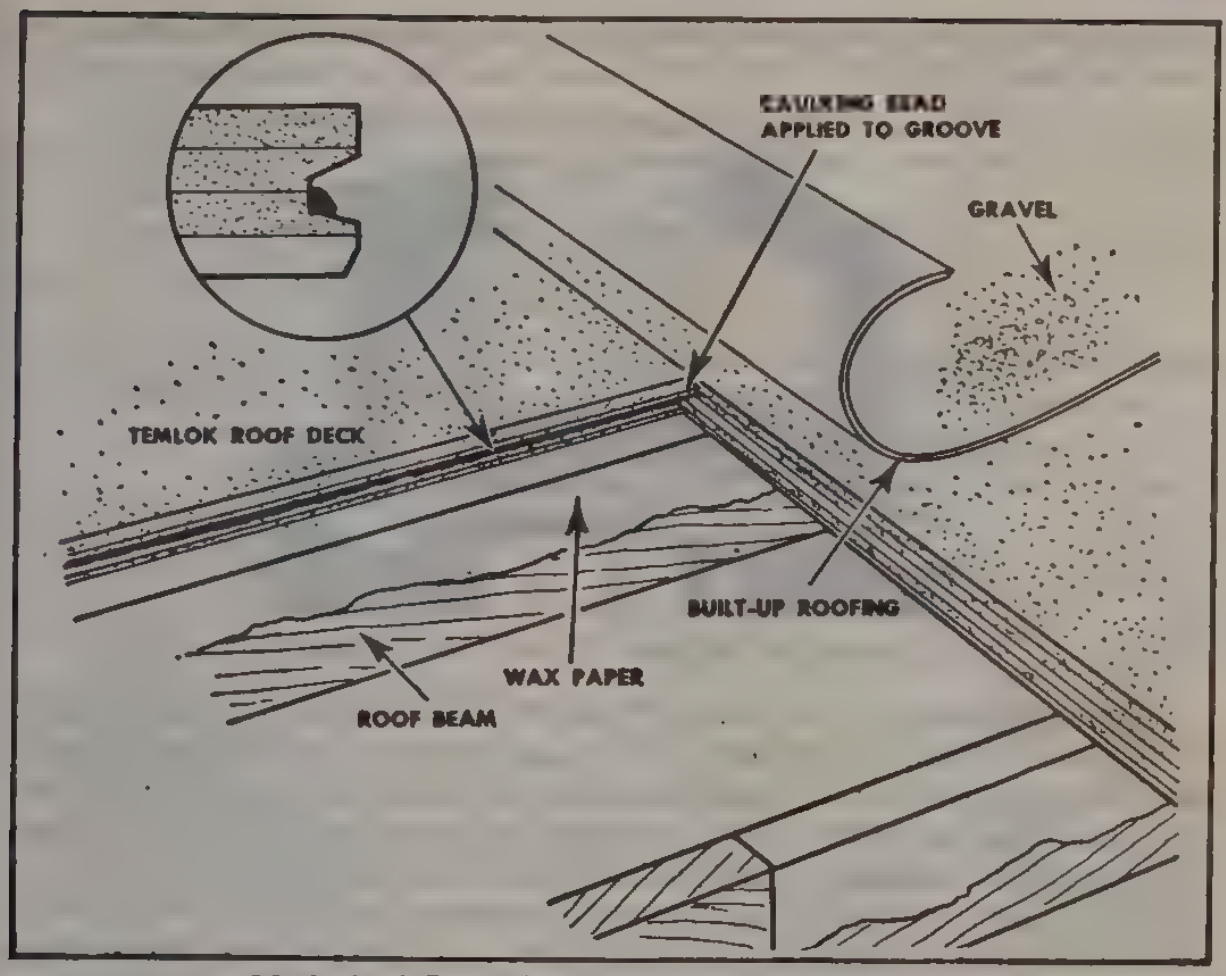
Decking should be laid so that cross joints are staggered and occur only over supports. Decking should be face-nailed to all framing members, spacing nails 4" to 6" apart and keeping back ¾" to 1" from edges of plank. Nails should be galvanized common of sufficient length to pass through decking and penetrate supports at least 1½" and should be driven flush but not countersunk. Where underside of decking will be exposed, planks must be handled and laid with care to prevent finished ceiling surface from being marred or damaged—avoid excessive sliding of plank on roof beams.

Estimating Data on Insulating Roof Decking

Thickness	Max. Distance Between Supports	Size & Type of Nails	Nails Req'd. Per 100 Sq. Ft.	Approx. Price Per Sq. Ft.
1½"	24"	10d Com. Galv.	6.0 lbs.	$0.35
2"	32"	16d Com. Galv.	3.5 lbs.	.42
3"	48"	30d Com. Galv.	3.0 lbs.	.56

Labor Placing Insulating Roof Decking.—The labor cost of handling and placing insulating roof decking will be about the same for the various thicknesses available, as the saving in handling the lighter material is offset by the increased nailing required due to closer allowable spacing of supports.

On simple, rectangular, flat or low-rise roofs, two carpenters and a helper should place 750 to 850 sq. ft. of decking per 8-hr.



Method of Installing Insulating Roof Decking.

day, including stapling paper strips on roof beams for added protection against marring finished surface, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50
Labor	1	.....	.....	5.00	5.00
Cost per 100 sq. ft. ...	3		$.....		$18.50
Cost per sq. ft.....			.....		.19

For steep roofs, with a slope greater than 6″ in 12″, add 15 to 25 percent.

Plyscord Sheathing and Subflooring

Douglas Fir plywood is available in a grade known as Plyscord used for wall and roof sheathing, subflooring, etc. It is available in panels 3′-0″ and 4′-0″ wide and 6, 7, 8, 9 and 10 feet long, in $\frac{5}{16}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$ and $\frac{3}{4}$-in. thicknesses. Panels are scored 16-in. on centers for ease of nailing.

Exterior walls are sheathed with $\frac{5}{16}$″ and $\frac{3}{8}$″ thicknesses, to which wood shingles may be directly applied. The sheathing should be applied with 6d nails, spaced 6-in. apart at all edge bearings and 12-in. apart elsewhere.

For roof sheathing, the thickness will depend upon the rafter spacing and the total roof load.

Method of Applying Plyscord Sheathing

For subflooring, $\frac{5}{8}$ or $\frac{3}{4}$-in. Plyscord is generally recommended with joists 16-in. on centers. The panels should be applied lengthwise across joists, with ends bearing on joists. Plyscord subflooring should be nailed to joists with 8d common nails, approximately 6 in. apart at all edges and 10 in. apart at interior joists.

Approximate prices on Plyscord sheathing are as follows: $\frac{5}{16}$-in. $100.00 to $110.00; $\frac{3}{8}$-in. $110.00 to $120.00; $\frac{1}{2}$-in. $140.00 to $150.00; $\frac{5}{8}$-in. $150.00 to $160.00; and $\frac{3}{4}$-in. $210.00 to $220.00 per 1,000 sq. ft.

Labor cost applying, same as given for insulating sheathing.

Cost of 100 Sq. Ft. of Structural Insulating Sidewall Sheathing Applied to Square or Rectangular Buildings of Regular Construction

	Hours	Rate	Total	Rate	Total
105 sq. ft. insulating sheathing		$.....	$.....	$10.00	$10.50
1 lb. galvanized nails		.....	.....	.18	.18
Carpenter sheathing	1.0	.....	.....	6.75	6.75
Helper unloading and carrying sheets	0.3	.....	.....	5.00	1.50
110 sq. ft. waterproof building paper		.....	.....	.007	.77*
Carpenter applying paper	0.4	.....	.....	6.75	2.70
Cost per 100 sq. ft.	1.7		$.....		$22.40
Cost per sq. ft.			.....		.22

*Paper optional, except under stucco, as insulating sheathing is treated to resist moisture.

If used on buildings of irregular construction, as described above, add 1-hr. carpenter time.

If 1x8-in. shiplap is used instead of 1x6-in. D&M lumber, deduct 5 ft. lumber b.m. and 0.1-hr. carpenter time per 100 sq. ft. of wall.

If used on buildings of irregular construction, as described above, add 1-hr. carpenter time.

Cost of 100 Sq. Ft. of 1x6-In. Dressed and Matched Wood Sidewall Sheathing Applied Horizontally to Square or Rectangular Buildings of Regular Construction

	Hours	Rate	Total	Rate	Total
120 ft. b.m. 1"x6" No. 2 D&M sheathing		$.....	$.....	$0.115	$13.80
1 lb. nails		.....	.....	.12	.12
Carpenter sheathing	1.5	.....	.....	6.75	10.125
Labor unloading and carrying lumber	0.5	.....	.....	5.00	2.50
110 sq. ft. waterproof building paper		.....	.....	.007	.77
Carpenter applying paper	0.4	.....	.....	6.75	2.70
Cost per 100 sq. ft.	2.4		$.....		$30.015
Cost per sq. ft.			.....		.30

Cost of 100 Sq. Ft. of 1x6-In. Dressed and Matched Wood Sidewall Sheathing Applied Diagonally to Square or Rectangular Buildings of Regular Construction

	Hours	Rate	Total	Rate	Total
125 ft. b.m. 1"x6" No. 2 D&M sheathing		$.....	$.....	$0.115	$14.38
1 lb. nails		.....	.....	.12	.12
Carpenter sheathing	2.0	.....	.....	6.75	13.50
Labor unloading and carrying lumber	0.5	.....	.....	5.00	2.50
110 sq. ft. waterproof building paper		.....	.....	.007	.77
Carpenter applying paper	0.4	.....	.....	6.75	2.70
Cost per 100 sq. ft.	2.9		$.....		$33.97
Cost per sq. ft.			.....		.34

If 1x8-in. shiplap is used instead of 1x6-in. D&M lumber, deduct 5 ft. lumber b.m. and 0.1-hr. carpenter time per 100 sq. ft. of wall.

If used on buildings of irregular construction, as described above, add 1-hr. carpenter time.

Cost of 100 Sq. Ft. of $\frac{5}{16}$-in. Plyscord Fir Plywood Sidewall Sheathing Applied to Square or Rectangular Buildings of Regular Construction

	Hours	Rate	Total	Rate	Total
105 sq. ft. Plyscord sheathing		$.....	$.....	$0.015	$11.03
1 lb. nails		.....	.....	.12	.12
Carpenter sheathing	1.0	.....	.....	6.75	6.75
Helper unloading and carrying sheets	0.3	.....	.....	5.00	1.50
110 sq. ft. waterproof building paper		.....	.....	.007	.77*
Carpenter applying paper	0.4	.....	.....	6.75	2.70*
Cost per 100 sq. ft.	1.7		$.....		$22.87
Cost per sq. ft.			.....		.23

*Paper optional as Plyscord comes in large sheets 48"x96" but is not treated with asphalt.

If used on buildings of irregular construction, as described above, add 1-hr. carpenter time.

Gypsum Sheathing.—Gypsum sheathing is a fireproof solid sheet of gypsum encased in a tough, fibrous, water-resisting covering. The sides and ends are treated to resist moisture. Some manufacturers blend asphalt emulsion into the wet gypsum core mix to provide additional resistance to moisture. It is used for sheathing on frame structures under siding, shingles, stucco and brick veneer.

Gypsum sheathing has V-joint edges on the long dimension to provide positive assurance of a tight fit at the unsupported joints. It is applied with its length at right angles to the studs.

Gypsum sheathing is $\frac{1}{2}$-in. thick, 2 ft. wide and 8 and 10 ft. long, and 4 ft. wide and 8 and 9 ft. long to fit supports 16 in. on centers. Nails should be $1\frac{3}{4}$-in. long, No. $10\frac{1}{2}$ gauge, galvanized flat head roofing nails, spaced 4-in. on centers, except under wood siding and stucco, 8". Requires 14 to 21 lbs. per 1,000 sq. ft.

Price $56.00 to $63.00 per 1,000 sq. ft.

Labor cost same as given for insulating or plywood sheathing.

Cost of 100 Sq. Ft. of Gypsum Sidewall Sheathing Applied to Square or Rectangular Buildings of Regular Construction

	Hours	Rate	Total	Rate	Total
105 sq. ft. gypsum sheathing		$.....	$.....	$6.00	$ 6.30
1 lb. nails		.....	.....	.18	.18
Carpenter sheathing	1.0	.....	.....	6.75	6.75
Helper unloading and carrying sheets	0.3	.....	.....	5.00	1.50
110 sq. ft. waterproof building paper		.....	.....	.007	.77*
Carpenter applying paper	0.4	.....	.....	6.75	2.70*
Cost per 100 sq. ft.	1.7		$.....		$18.20
Cost per sq. ft.			.....		.18

*Paper optional as gypsum sheathing is now waterproofed sides and edges. Some manufacturers mix asphalt emulsion with wet gypsum to provide a waterproof board.

If used on buildings of irregular construction, as described above, add 1-hr. carpenter time.

Insulating Shingle Backer Strips

A number of manufacturers produce a shingle backer strip, of the same material as insulating sheathing board, to be used as the undercourse in double course shingle work. These strips are 4′-0″ long and either $\frac{5}{16}$″ or $\frac{3}{8}$″ thick. They are available in two widths, 13½″ for 12″ shingle exposure and 15½″ for 14″ shingle exposure. They provide added insulation, improve the shadow line appearance of the finished wall, eliminate the necessity of building paper over wood sheathing and are more economical to use than second grade wood shingle undercoursing. Insulating shingle backer strips cost approximately 6¼ cts. per sq. ft.

Labor Placing Insulating Shingle Backer Strips.—On straight run jobs, with an average number of openings, a carpenter should place 500 to 600 sq. ft. of shingle backer strips per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$.....	$.....	$6.75	$10.125
Labor	0.5	.....	.....	5.00	2.50
Cost 100 sq. ft.	2.0		$.....		$12.625
Cost per sq. ft.					1.26

On complicated jobs, requiring a large amount of cutting and fitting, a carpenter should place 400 to 500 sq. ft. per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.8	$.....	$.....	$6.75	$12.15
Labor	0.5	.....	.....	5.00	2.50
Cost 100 sq. ft.	2.3		$.....		$14.65
Cost per sq. ft.			.....		.15

Cemesto* Structural Insulating Panels.—A structural insulating unit consisting of a core of laminated cane fiber insulating board surfaced on both sides with asbestos-cement board using a moisture-proof bituminous adhesive as a bond between the asbestos-cement and core material. The panel provides structural strength, insulation and maintenance-free exterior and interior finish in a single thickness. This material is used in all types of buildings for exterior walls, roof decks, partitions and as a lining material. It may be applied to steel or wood framing using bolts and clips, screws or nails. Nailing will not fracture the surface when reasonable care is used in driving. It is workable with ordinary carpenter tools but, for large volume cutting and drilling, carboloy tipped tools are more efficient.

Cemesto is furnished in sheets 4′-0″ wide and from 4′-0″ to 12′-0″ long in 2′-0″ increments. Panel thicknesses available are $\frac{11}{16}$″, $1\frac{1}{8}$″, $1\frac{5}{16}$″ and 2″.

Thickness, Weight and Approximate Prices of Cemesto Sheets

Thickness Inches	Approximate Weight in Lbs. per Sq. Ft.	Approximate Price per Sq. Ft.
$\frac{11}{16}$	3.5	$0.31
$1\frac{1}{8}$	3.9	.38
$1\frac{5}{16}$	4.7	.45
2	5.4	.52

Labor Installing Cemesto Board as Roof Decking.—When $1\frac{5}{16}$″ or 2″ Cemesto board is used for roof decking over wood or steel framing, 4 carpenters and 2 laborers working together should place 1,500 to 1,600 sq. ft. of decking per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.10	$.....	$.....	$6.75	$14.18
Labor	1.05	.....	.....	5.00	5.25
Cost 100 sq. ft.	3.15		$.....		$19.43
Cost per sq. ft.			.....		.19

Add for caulking joints with plastic roofing cement and covering joints with 6″ wide strips of saturated fabric or 30-lb. roofing felt.

*Celotex Corporation, Chicago, Illinois.

Labor Installing Cemesto Board as Curtain Walls.—When 1⅛", 1 9/16" or 2" Cemesto board is applied as curtain walls on wood or steel framing, 2 carpenters and 2 laborers working together should place 325 to 375 sq. ft. of curtain wall per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	4.6	$.....	$.....	$6.75	$31.05
Labor	4.6	.....	.....	5.00	23.00
Cost 100 sq. ft.	9.2		$.....		$54.05
Cost per sq. ft.					.54

Add for caulking joints and covering joints with batten strips or metal plates.

Labor Installing Cemesto Board as Partitions.—When Cemesto boards are used for partitions, several methods of framing may be employed, however, very little difference in labor placing the panels should be experienced.

In general, floor and ceiling plates, either rabbeted or built up to form a retaining slot, are installed and Cemesto panels are set in place. Joints between panels may be covered with battens, concealed with metal flush panel mouldings or splined together. In some instances 2"x4" studs and plates are used, the studs being spaced to allow one full panel to be installed between them and stops being used to hold the panels in place.

After framing is in place, 2 carpenters and 1 laborer working together should place 1,350 to 1,450 sq. ft. of partition panels per 8-hr. day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.2	$.....	$.....	$6.75	$ 8.10
Labor	0.6	.....	.....	5.00	3.00
Cost 100 sq. ft.	1.8		$.....		$11.10
Cost per sq. ft.					1.11

Add for joint treatment required.

Insulating Lath

Insulating lath are made by several manufacturers of insulating building sheathing. They are made of the same materials as the building boards previously described.

Insulating lath is usually furnished in the 18"x48" size, ½", ¾" and 1" thick, although they are obtainable from some sources 16"x48".

Some manufacturers furnish lath both plain and with the back coated with asphalt to form a vapor barrier.

Most insulating lath are manufactured with the long edges shiplapped and all edges beveled to reinforce the plaster against cracking and eliminate unsightly lath marks. Some of these insulating lath are metal reinforced along the edges to reinforce the unsupported horizontal joint.

Insulating gypsum lath consists of regular gypsum board lath with a thin sheet of aluminum attached to one side to provide insulating value. They are furnished in sheets 16x32-in., 16x48-in., and $\frac{3}{8}$ and $\frac{1}{2}$-in. thick.

Estimating Quantities of Insulating Lath

Size of Lath in Inches	No. Sq. Ft. per Lath	No. Lath per 100 Sq. Ft.
16x48	5.33	18.76
18x48	6.00	16.67

Approximate prices of insulating lath are as follows per 1,000 sq. ft.: $\frac{1}{2}$-in. $72.00; $\frac{3}{4}$-in. $105.00; 1-in. $135.00.

Labor Applying Insulating Lath.—The labor cost of applying insulating lath will vary with the locality and labor restrictions. Where there are no labor restrictions, an experienced man should place 125 sq. yds. per 8-hr. day; while in the larger cities a lather will place only 100 sq. yds. per 8-hr. day, at the following labor cost per 100 sq. yds.:

	Hours	Rate	Total	Rate	Total
Lather	8	$.....	$.....	$6.50	$52.00
Cost per sq. yd.			.....		.52

GLASS WOOL, MINERAL WOOL, ROCK WOOL AND COTTON INSULATION

Glass, mineral or rock wool insulation is made of glass, rock or silica, molten at high temperatures and blown into fine thread-like particles, which when cooled forms a wool-like substance that is used for insulation between studs, ceiling joists and roof rafters, also for deadening between floors and partitions. Glass or rock wool is fireproof and vermin-proof.

Glass or rock wool is furnished in many different forms by the various manufacturers. It may be obtained in loose form; in granulated or pellet form; in strips of various widths and lengths, and in batts of various sizes. Practically all glass or rock wool is waterproofed to resist moisture.

In order to avoid confusion regarding the various materials and to include all of them the term "Insulating Wool" will be used to include all materials: glass, mineral, rock or silica.

Insulating Wool Batts.—Insulating wool batts are recommended for new construction on account of their ease in handling and placing, as they are furnished in widths that fit between studs without cutting or fitting.

Insulating wool batts are furnished with and without paper backing. Where paper backed batts are used, a heavy waterproof paper, highly vapor resistant, is cemented to the back of each batt. This paper backing extends 1½ to 2 inches on each side forming nailing flanges to hold the wool in place. The paper should always be applied facing the warm side. Foil backed batts are also available. The average density of insulating wool batts is 4¾ to 5 lbs. per cu. ft.

Sizes and Covering Capacity of Glass, Mineral or Rock Wool Batts

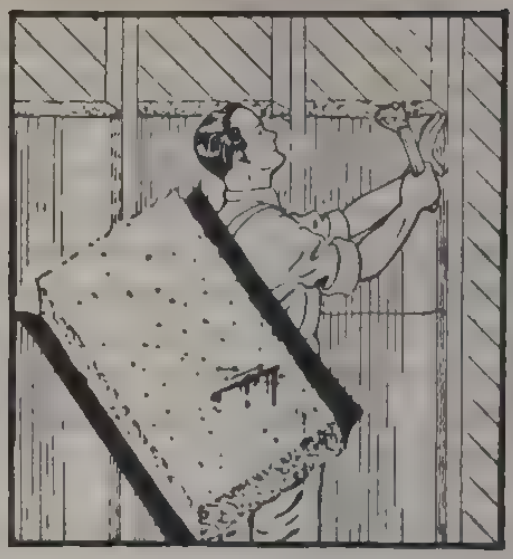
Size of Batts in Inches	Thickness Inches	Sq. Ft. per Batt Excluding 2x4's	Sq. Ft. per Batt Including 2x4's	No. Batts Required 100 Sq. Ft. of Wall Excluding 2x4's	No. Batts Required 100 Sq. Ft. of Wall Including 2x4's
15x24	2	2.50	2.67	40	38
15x24	3	2.50	2.67	40	38
15x48	2	5.00	5.33	20	19
15x48	3	5.00	5.33	20	19
19x24	2	3.17	3.33	32	30
19x24	3	3.17	3.33	32	30
19x48	2	6.33	6.67	16	15
19x48	3	6.33	6.67	16	15
23x24	2	3.84	4.00	26	25
23x24	3	3.84	4.00	26	25
23x48	2	7.67	8.00	13	13
23x48	3	7.67	8.00	13	13

Approx. prices of insulating wool batts: 2″ thick, 5 to 5½ cts. per sq. ft.; 3″ thick, 6 to 7 cts. per sq. ft.

Labor Placing Insulating Wool Batts.—Insulating wool batts are easily handled and can be placed by any building laborer, but are usually placed by carpenters. Naturally, it will require a little time to become accustomed to handling and placing them but with a little experience, a man should place and staple wool batts over 700 to 800 sq. ft. of wall per 8-hr. day, at the following labor cost per 100 sq ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	1.25	$.....	$.....	$6.75	$8.44
Cost per sq. ft.					.84

Method of Placing Insulating Wool Batts.



Method of Placing and Stapling Paper-Backed Insulating Wool Batts.

Strip Insulating Wool.—Insulating wool is furnished in strips 1, 2 and 3-in. thick, 15 and 23 inches wide to fit between joists or studs, and in lengths from 6 to 80 feet, depending upon the thickness and types.

Some strip wool is furnished without paper backing, while other manufacturers furnish the strip wool with a heavy waterproof paper, highly vapor resistant, cemented to the back of each strip. The paper backing extends 2 inches on each side forming nailing flanges to hold the wool in place and should be installed with paper backing facing warm side to act as a vapor barrier.

Insulating wool is furnished in strips without paper backing, 15 in. wide, and 1, 2 and 3-in. thick. The paper backed strips are 15 and 23 inches wide, 2 and 3 inches thick and the strips are up to 80 feet long.

Strip insulating wool 1 inch thick costs 3 to 3½ cts. per sq. ft. Other strip wool costs approximately the same as batts.

Labor cost applying strip insulating wool the same as insulating wool batts.

Loose Insulating Wool.—Loose insulating wool is the basic long fiber as originally produced. It is suitable for any purpose where insulation can be packed by hand between ceiling joists or side wall studding. For maximum results it is recommended that wool be applied full thickness of side wall studding and approximately 4 inches over ceiling areas.

Method of Placing Strip Insulating Wool.

The covering capacity varies considerably with the density to which it is packed.

The National Bureau of Standards conductivity figure for glass or rock wool is 0.27 b.t.u. at a density of 10 lbs. per cu. ft.

The covering capacity of bulk wool as given by most manufacturers is based on a density of 6 to 8 lbs. per cu. ft.

Number of Sq. Ft. of Surface Covered By One Bag of Loose Insulating Wool Weighing 40 Lbs. and Containing 4 Cu. Ft. Not Including Area Covered By Studs or Joists

Density per Cu. Ft. Lbs.	Actual Cu. Ft.	Thickness of Loose Insulating Wool in Inches 1	2	3	3½	3⅝	4
6	6.67	80.0	40.0	26.6	22.8	22.0	20.0
7	5.72	68.5	34.4	22.9	19.7	18.8	17.2
8	5.00	60.0	30.0	20.0	17.2	16.6	15.0
9	4.45	53.4	26.7	17.8	15.2	14.7	13.4
10	4.00	48.0	24.0	16.0	13.7	13.3	12.0

Number of Sq. Ft. of Surface Covered By One Bag of Loose Insulating Wool Weighing 40 Lbs. and Containing 4 Cu. Ft. Including Area Covered By Studs or Joists

Density per Cu. Ft. Lbs.	Actual Cu. Ft.	Thickness of Loose Insulating Wool in Inches 1	2	3	3½	3⅝	4
6	6.67	85.0	42.5	28.4	24.3	23.5	21.2
7	5.72	73.0	36.5	24.3	20.8	20.0	18.3
8	5.00	63.8	31.9	21.3	18.3	17.6	16.0
9	4.45	56.7	28.4	18.9	16.2	15.7	14.2
10	4.00	51.0	25.5	17.0	14.5	14.1	12.7

Number of Sq. Ft. of Surface Covered By One Ton (2,000 Lbs.) of Loose or Granular Insulating Wool of Varying Thicknesses, Not Including Area Covered By Studs or Joists

Density per Cu. Ft. Lbs.	Actual Cu. Ft.	Thickness of Loose Insulating Wool in Inches 1	2	3	3½	3⅝	4
5	400	4,800	2,400	1,600	1,372	1,325	1,200
6	333	3,996	1,998	1,332	1,132	1,103	999
7	286	3,432	1,716	1,144	982	948	858
8	250	3,000	1,500	1,000	858	828	750
9	222	2,664	1,332	888	762	736	666
10	200	2,400	1,200	800	686	663	600

Number of Sq. Ft. of Surface Covered By One Ton (2,000 Lbs.) of Loose or Granular Insulating Wool of Varying Thicknesses, Including Area Covered By Studs or Joists

Density per Cu. Ft. Lbs.	Actual Cu. Ft.	Thickness of Loose Insulating Wool in Inches 1	2	3	3½	3⅝	4
5	400	5,100	2,550	1,700	1,458	1,408	1,275
6	333	4,245	2,122	1,415	1,204	1,173	1,060
7	286	3,650	1,825	1,216	1,044	1,008	912
8	250	3,190	1,595	1,062	912	880	797
9	222	2,830	1,416	944	810	782	708
10	200	2,550	1,275	850	729	705	638

Loose or bulk rock wool is usually furnished in bags weighing 40 lbs. and containing 4 cu. ft. Average price $1.00 to $1.10 per bag, or $50.00 to $55.00 per ton.

Granule or Pellet Type Insulating Wool.—Granule or pellet type insulating wool is furnished in particles sufficiently large that the material will not sift or dust through wall or ceiling cracks and is used for insulating ceiling areas between supporting joists, or of void wall spaces where accessible and which permit of pouring the pellets into place, particularly in old house construction.

Granule or pellet type insulating wool is usually furnished in bags weighing 40 lbs. and is placed at a density of 7 to 8 lbs. per cu. ft.

The tables for loose or granular insulating wool, based on 7 to 8 lbs. per cu. ft. may be used for estimating quantities obtainable per bag or per ton.

Granule or pellet type insulating wool in bags or cartons weighing 40 lbs. cost $1.10 to $1.30, or $55.00 to $65.00 per ton.

In old work and in open spaces in new buildings it is much more economical to have the insulating wool blown in between the studs and joists as this eliminates all handling and placing

of wool by hand. There are many insulation contractors who specialize in this class of work and can do it cheaper, including their profit, than the average contractor handling an occasional job.

Labor Placing Loose or Bulk Insulating Wool.—When placing loose or bulk insulating wool between wood studs, a man should place about 350 to 450 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	2	$.....	$.....	$5.00	$10.00
Cost per sq. ft.			.....		.10

Labor Placing Granule or Pellet Type Insulating Wool Between Ceiling Joists.—Where granule or pellet type insulating wool is poured between ceiling joists and other open spaces, to a thickness of 3½ or 3⅝-in. a man should place 700 to 900 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor	1	$.....	$.....	$5.00	$5.00
Cost per sq. ft.			.....		.05

Glass, Mineral or Rock Wool.—Inasmuch as mineral or rock wool is made of rock, silica or glass, molten at high temperatures and blown into fine thread-like particles, the difference in name is merely the materials from which they are made. Those made from rock are called rock wool while those made from silica or glass are called glass or mineral wool.

Otherwise the materials are similar and are used for the same general purpose, whether called glass wool, rock wool or mineral wool.

Cost of 100 Sq. Ft. of Wall Insulation Using Insulating Wool Batts 3-In. Thick

	Hours	Rate	Total	Rate	Total
100 sq. ft. wool batts		$.....	$.....	$0.07	$ 7.00
Carpenter	1.1	.....	.....	6.75	7.43
Cost 100 sq. ft.	1.1		$.....		$14.43
Cost per sq. ft.			.....		.144

Cost of 100 Sq. Ft. of Ceiling Insulation Using Granule Insulating Wool 4-In. Thick, Packed to a Density of 7 Lbs. Per Cu. Ft.

	Hours	Rate	Total	Rate	Total
6 bags (40 lbs. each) granule rock wool		$.....	$.....	$1.20	$ 7.20
Labor placing	1	.....	.....	5.00	5.00
Cost 100 sq. ft.	1		$.....		$12.20
Cost per sq. ft.			.....		.12

Cost of 100 Sq. Ft. of Ceiling Insulation Using Granule Insulating Wool 4-In. Thick, Packed to a Density of 8 Lbs. Per Cu. Ft.

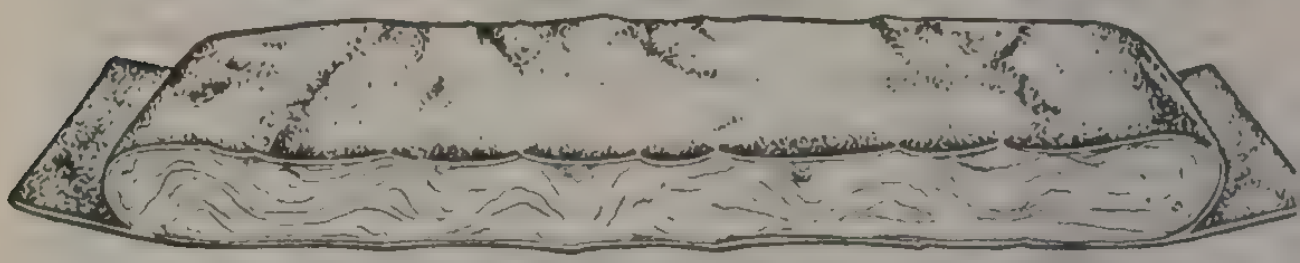
	Hours	Rate	Total	Rate	Total
7 bags (40 lbs. each) granule rock wool		$.....	$.....	$1.20	$ 8.40
Labor placing	1.1	.....	.....	5.00	5.50
Cost 100 sq. ft.....	1.1		$.....		$13.90
Cost per sq. ft.....			.....		.14

Cost of 100 Sq. Ft. of Ceiling Insulation Using Granule or Pellet Type Insulating Wool Poured Between Ceiling Joists, 6-In. Thick

	Hours	Rate	Total	Rate	Total
10 bags (40 lbs. each) granule rock wool		$.....	$.....	$1.20	$12.00
Labor placing	1.5	.....	.....	5.00	7.50
Cost 100 sq. ft.....	1.5		$.....		$19.50
Cost per sq. ft.			.....		.20

Cotton Insulation.—Cotton insulation consists of minute cellulose fibers derived from the cotton plant and intertwined into a compact but extremely lightweight and resilient mass. They entwine and interlock into a white, clean blanket of cohering dead air cells retarding the movement of heat.

Cotton insulation is used in much the same way as mineral, glass or rock wool, except it is lighter in weight. It is chemically treated so that it does not support combustion when subjected for 20 minutes to a 1,600° F. flame from a blowtorch. The basic cellular fibres of cotton insulation are non-absorbent and impervious to moisture, and treated to repel vermin.



Cotton insulation is furnished in rolls 15" wide for 16" stud or joist spacing, has a 1¼" flange for nailing, and is furnished as a closed blanket, with a breather paper covering the top of the cotton; also with aluminum foil backing for maximum heat resistance and vapor protection.

The labor cost of applying cotton insulation is the same as given for other similar types of blanket or batt insulation.

Furnished in rolls in the following thicknesses:

Width Inches	Thickness Insulation	Weight per Sq. Ft.	Sq. Ft. in Roll	Price per Roll
15	1½"	.083 lb.	400	$22.00
15	2 "	.110 lb.	300	21.00

Vermiculite Loose-fill Building Insulation.—Vermiculite loose-fill insulation is used to insulate attics, lofts, and side walls. It is fireproof, not merely "fire resistant." The fusion point is 2200° to 2400° F.

It is completely mineral and does not decompose, decay, or rot. Because of its granular structure, vermiculite is free-flowing, assuring a complete insulation job without joints or seams. Rodents cannot tunnel into it, and it does not attract termites or other vermin. Vermiculite is a non-conductor and is excellent protection around electrical wiring.

Vermiculite loose-fill is marketed in 4 cu. ft. bags. Approximate coverage per bag, based on joists spaced 16" o.c., is 14 sq. ft. for a 3⅝" thickness; 9 sq. ft. for 5½" thickness.

Average material cost is 3¢ per bd. ft. Installation cost is minor because the material flows into place easily.

When adequate ventilation is provided in attics or similar spaces, it is not necessary to use a vapor barrier in the ceiling construction below vermiculite fill insulation. A vapor barrier is recommended on the warm side of insulated exterior walls, except

Leveling Off Vermiculite Loose-fill Poured Over Existing Insulation to Provide Additional Thickness.

when the insulated space is ventilated to permit movement of water vapor and air from the space. A satisfactory vapor barrier may be obtained by painting the interior surface of a wall with a good vapor barrier paint.

Reinsulation: Where an existing thickness of blanket or other insulation is inadequate, vermiculite fill can be poured over it to obtain the thickness desired.

For vermiculite masonry wall insulation, see Chapter X, Concrete Masonry, p. 580.

Roof Insulation

Roof insulation is furnished by many manufacturers of fiber building board and is of the same general composition as the building boards manufactured by them, such as Temlok, Celotex, Insulite, Masonite, Nu-Wood, etc.

They are available in ½", 1", 1½" and 2" thicknesses and may be obtained in any other thickness desired. In thicknesses of 1-in. or greater, multiples of ½-in. roof insulation laminated, with offset or flush edges, as desired and to required thickness. They are furnished in units 22x47-in.; 23x47-in.; 24x48-in. and 24x60-in.

Covering Capacity of Roof Insulation

Size of Boards in Inches	No. Sq. Ft. per Board	No. Boards per 100 Sq. Ft.
23x47	7.50	13.33
24x48	8.00	12.50

Approximate prices per 1,000 sq. ft. ½-in. thick, $60.00; 1-in. thick, $90.00; 1½-in. thick, $140.00 and 2-in. thick, $180.00.

For thicknesses greater than 2-in. add $50.00 to $60.00 per 1,000 sq. ft. for each additional ½-in. thickness.

Where the roof insulation is more than 1" thick, it is often built up by applying additional courses of ½" insulating board, with a mopping of hot pitch between each thickness of board.

Labor costs of applying roof insulation of various thicknesses is given under "Roofing."

CORKBOARD AND RIGID FOAM INSULATION

Corkboard is a board form insulating material used in cold storage warehouses, food and industrial processing plants, and wherever refrigeration is used to maintain temperatures at specified levels.

Rigid foam insulation is composed of expanded polystyrene, glass or polyurethane bound together into rigid board without

the use of additional binder. It has largely replaced corkboard for low temperature insulation. It is also used in general building for roofs, as it is quite strong, tough and resilient; for curtain wall back up as it is lightweight; for core walls as it is self-supporting; for perimeter and crawl space insulation as it has a low water absorption and a zero rating for capillary action. In addition, it forms a vapor barrier, can be used as a plaster base with some reservations, is dimensionally stable, incombustible, and easily cut.

When used with monolithic concrete, rigid foam insulation can be placed in the forms at the time of pouring. Existing concrete and masonry units can be covered by adhering units, by full back plastering with ½" portland cement plaster; with hot asphalt; or with gobs of cement holding units out ¼" from masonry.

Units come in 1", 1½", 2", 3", 4" and 6" thicknesses and sizes from 12"x18" to 36"x36" in packaged forms and up to 9' lengths when shipped in carload lots. There are no standard sizes within the industry and sizes, costs, and insulating values must be carefully checked with the various manufacturers. Urethane products in carton lots may be quoted at almost twice the cost of styrene or glass but the thermal conductivity of the urethane is .15 as compared to .25 to .30 for the other materials. One manufacturer lists its glass foam product in less than carload lots at 16 cts. a bd. ft. and its urethane at 24.5 cts. per bd. ft.

The following directions cover the erection of insulation in building construction of all kinds in general use. To secure satisfactory results, the manufacturer's specifications should be followed carefully.

Back Plaster.—Where insulation is to be applied against masonry walls in hot asphalt, the walls must be made true and even with portland cement plaster. The back plaster may be omitted if the wall is of poured concrete.

Back plaster should be made by mixing 1 part portland cement and 3 parts clean sharp sand. Back plaster ½-in. thick requires 3.75 bbls. portland cement and 1.67 cu. yds. of sand per 1,000 sq. ft.

Cost of One Cu. Yd. of 1:3 Portland Cement Back Plaster

	Rate	Total	Rate	Total
9.5 sacks portland cement	$.....	$.....	$1.80	$17.10
1.10 cu. yds. sand	.....	.....	4.00	4.40
Cost per cu. yd.		$.....		$21.50
Cost per cu. ft.		.....		.80

Asphaltic Priming Coat.—All concrete or plaster surfaces to

which insulation is to be applied in hot asphalt must be primed with asphaltic priming coat, made especially for this purpose.

Asphalt.—The proper grade of asphalt to be used is very important. It must be odorless, as any material with an odor will taint foodstuffs that may be stored in insulated rooms. It should be an oxidized asphalt of 180° F. to 200° F. melting point and should preferably be made from a Mexican base oil. The hot asphalt in which corkboard is dipped should be held between 350° and 375° F. Do not heat asphalt to higher temperatures than these. Most manufacturers recommend an asphalt for use with their product.

On dipping floor, wall and ceiling insulation allow .4 lbs. of asphalt per sq. ft. of insulation per layer. Mop coating on floors or top of ceiling requires .8 lbs. per sq. ft.

Cold Erection Plastic.—Where the use of hot asphalt for the erection of corkboard is not practical use cold erection plastic on floors, walls and ceilings. A $\frac{1}{16}$-in. thick coat requires 1-gal. of cold erection plastic per 25 sq. ft.

Nails or Impregnated Skewers.—Use nails for the attachment of the first layer of insulation to wood and frame construction, or for the attachment of the second layer to wood stripped concrete ceilings, or for toenailing the first layer of solid cork walls. All nails should be of galvanized wire and should be 1-in. longer than the thickness of the insulation. Where two courses of insulation are erected in hot asphalt or cold erection plastic, impregnated hardwood skewers should be used to additionally secure the second course in position. Do not use either nails or skewers when erecting the first course against brick, stone or concrete walls. Hot asphalt or cold erection plastic is all that is required.

Finishes.—Corkboard insulation should receive a finish which will give long service under the temperature and moisture conditions common to cold storage rooms. The finish should bond securely to the corkboard and be reasonably resistant to bumps and abrasion. Cost, good appearance, and availability should also be considered. These requirements are best met by asphalt emulsion finishes or portland cement plaster. Asphalt emulsion finishes are generally used on ceilings and portland cement plaster on walls. Rigid foam insulations may be sprayed or brushed with special white vinyl emulsion paints.

Asphalt emulsion finishes shall be applied directly to corkboard in two coats, each $\frac{1}{8}$" thick. Before applying the first coat, all voids, open joints, or broken corners must be pointed with emulsion finish. The first coat must be hand dry before the second coat is applied. Trowel the second coat smooth. The final

thickness of the finish shall be approximately ⅛" when dry. Finish all corners true and clean.

The emulsion finishes must be thoroughly dry before any paint is applied, to guard against cracking.

The cost of 100 sq. ft. of asphalt emulsion finish coat should average as follows:

	Hours	Rate	Total	Rate	Total
First Coat					
2.5 gals. Plastic Emulsion		$.....	$.....	$0.85	$ 2.13
Mechanic	2	.....	.....	6.00	12.00
Second Coat					
2.5 gals. Plastic Emulsion		.....	.....	.85	2.13
Mechanic	2	.....	.....	6.00	12.00
Cost 100 sq. ft.	4		$.....		$28.26
Cost per sq. ft.					.28

The cost of 100 sq. ft. of ½" of 1:3 portland cement plaster should average as follows:

	Hours	Rate	Total	Rate	Total
5 cu. ft. 1:3 cement mortar		$.....	$.....	$0.80	$ 4.00
Mechanic	3	.....	.....	6.00	18.00
Helper	3	.....	.....	5.00	15.00
Cost per 100 sq. ft.	6		$.....		$37.00
Cost per sq. ft.					.37

Portland cement plaster should be mixed in the proportions of 1 part portland cement, 3 parts clean, screened sand, and 5 percent hydrated lime.

To reduce cracking to a minimum, finish coat of plaster may be scored each way approximately 4'-0" on centers.

Some manufacturers state plaster can be applied directly to insulation; others specify wire mesh must be applied, particularly on ceiling work. As rigid foam insulation does not absorb water, plaster coats will dry very slowly. It is also necessary to add the cost of nailer strips for casings, trim and bases, if any occur. Light trim such as beads may be stapled on.

Erection Costs.—The costs of erecting insulation, as given on the following pages, are for straight work. Please bear in mind that columns, beams, pilasters and other structural irregularities cannot be insulated at the costs given, but the estimator will have to take these conditions into consideration and figure higher than for straight surfaces, according to conditions.

The following tables are based on using 2" insulation. If 3", 4" or 6" thicknesses are used, add difference in cost of material, plus about ½-hr. mechanic and 1-hr. helper, per 100 sq. ft.

Subcontractor's Overhead Expense and Profit.—This type of insulation is usually sublet to a contractor specializing in this class of work, as they have experienced men and the necessary

equipment to perform the work more efficiently than the average general contractor. When subletting work of this kind, it will be necessary to add for employee's transportation, board, etc., plus 25 to 30 percent for subcontractor's overhead expense and profit.

Cost of 100 Sq. Ft. of Two Layers of Insulation, Set in Hot Asphalt Against Masonry Walls.

Masonry walls plastered with ½" of 1:3 cement plaster; an asphaltic priming coat and 2 layers of 2" insulation set in hot asphalt.

	Hours	Rate	Total	Rate	Total
5 cu. ft. cement mortar..		$.....	$.....	$0.80	$ 4.00
Mechanic	2	.....	.....	6.00	12.00
Helper	2	.....	.....	5.00	10.00
1 gal. asphalt priming coat		.....	.....	.75	.75
200 sq. ft. 2" corkboard..		.....	.....	.30	60.00
80 lbs. erect. asphalt.....		.....	.....	.025	2.00
Nails and skewers.....		.....	.....	.50	.50
Mechanic	3	.....	.....	6.00	18.00
Helper	6	.....	.....	5.00	30.00
Cost 100 sq. ft.....	13		$.....		$137.25
Cost per sq. ft.			.....		1.37

If applied against poured concrete walls, omit cement back plaster and labor applying same. Add for finish coat according to specifications.

Cost of 100 Sq. Ft. of Two Layers of Insulation, First Layer in ½-in. Cement Mortar and Second Layer in Hot Asphalt, Against Masonry Walls.

Masonry walls must be thoroughly cleaned of dirt, dust, loose mortar, etc., and where necessary, roughened or hacked to ensure a good bond.

	Hours	Rate	Total	Rate	Total
5 cu.ft. 1:3 cement mortar		$.....	$.....	$0.80	$ 4.00
200 sq. ft. 2" insulation....		.....	.....	.30	60.00
40 lbs. erect. asphalt....		.....	.....	.025	1.00
Nails and skewers		.....	.....	.50	.50
Mechanic	3	.....	.....	6.00	18.00
Helper	6	.....	.....	5.00	30.00
Cost 100 sq. ft.....	9		$.....		$113.50
Cost per sq. ft.....			.....		1.14

If 3", 4" or 6" insulation is used, add ½-hr. mechanic and 1-hr. helper time per 100 sq. ft., plus additional cost of corkboard.

Add for finish coat according to specifications.

Cost of 100 Sq. Ft. of Two Layers of 2-In. Corkboard to Concrete Floor or Ceiling, First Layer Set in Forms, Second Layer in Hot Asphalt after Forms are Removed

The building contractor shall depress the concrete forms to the proper elevation to receive the first layer of insulation, and shall remove them after the concrete slab has set, care being taken that the insulation is left undamaged.

Set the first layer of insulation directly in the forms with all joints tight. Three nails per sq. ft. shall be driven obliquely into the top surface with heads protruding. After the forms have been removed, apply the second layer of insulation in hot asphalt against the underside of the first layer and additionally secure it with special pins of proper length. Finish the exposed insulation surfaces.

First Layer in Forms	Hours	Rate	Total	Rate	Total
100 sq. ft. 2″ insulation..		$.....	$.....	$0.30	$ 30.00
Nails		.....	.....	.50	.50
Mechanic	1.5	.....	.....	6.00	9.00
Helper	3.0	.....	.....	5.00	15.00
Second Layer					
100 sq. ft. 2″ insulation..		.....	.....	.30	30.00
40 lbs. erect. asphalt.....		.....	.....	.025	1.00
Fasteners		.....	.....	.50	.50
Mechanic	2.0	.....	.....	6.00	12.00
Helper	4.0	.....	.....	5.00	20.00
Cost 100 sq. ft.....	10.5		$.....		$118.00
Cost per sq. ft.			.....		1.18

Add for asphalt finish coat according to specifications.

Cost of 100 Sq. Ft. of Two Layers of 2-In. Insulation Applied to Wood Ceiling or Roof Deck (Insulation on Top), Both in Hot Asphalt

Provide a slot 1″ wider than the thickness of the wall insulation along all walls so that the wall and ceiling (roof) insulation will join.

On top of the wood ceiling structure tack one layer of heavy asphalt paper with the edges lapped at least 3″ and sealed with hot asphalt.

Over this apply insulation, each layer being laid in and flooded with hot asphalt.

	Hours	Rate	Total	Rate	Total
110 sq. ft. asphalt paper..		$.....	$.....	$0.007	$ 0.77
200 sq. ft. 2" insulation....		.....	.....	.30	60.00
160 lbs. erect. asphalt....		.....	.....	.025	4.00
Mechanic	3	.....	.....	6.00	18.00
Helper	6	.....	.....	5.00	30.00
Cost 100 sq. ft.....	9		$.....		$112.77
Cost per sq. ft.....			.....		1.13

Add for finish coat according to specifications.

Cost of 100 Sq. Ft. of One Layer of 2-In. Insulation Applied Over Concrete Ceiling or Roof Slab

Provide in the concrete slab a slot 1" wider than the thickness of the wall insulation along all walls if that wall and ceiling insulation will join.

Apply the insulation directly to the concrete slab, each layer being laid in and flooded with hot asphalt.

	Hours	Rate	Total	Rate	Total
100 sq. ft. 2" insulation....		$.....	$.....	$0.30	$30.00
120 lbs. erect. asphalt....		.....	.....	.025	3.00
Mechanic	1.5	.....	.....	6.00	9.00
Helper	3	.....	.....	5.00	15.00
Cost 100 sq. ft.....	4.5		$.....		$57.00
Cost per sq. ft.....			.....		.57

Add for finish coat according to specifications.

METAL WEATHER STRIPS

The cost of metal weather strips will vary with the type of window, whether double hung or casement, size of opening, thickness of sash, etc., as they all affect the material and labor costs. It will make considerable difference in the labor costs whether the weather strips are installed in an occupied or unoccupied building. Ordinarily a workman must use more care when working in an occupied building and for that reason it will require ¼ to ½ hour more time per opening than when working in new or unoccupied buildings.

The following quantities and costs are based on using men experienced in placing weather strips.

Metal Weather Strips for Double Hung Windows.—When weatherstripping double hung windows, standard specifications require a track strip at least ¾" wide at the top and bottom of the

window, side strips for the lower sash not less than $\frac{1}{16}$" wider than the width of the sash runway and side strips for the upper sash not less than $\frac{1}{16}$" narrower than the width of the sash runway. Meeting rails to receive two interlocking hook strips or interlocking hook and flat strips.

When estimating the quantities of weather stripping required take the distance around the window, for the sides, head and sill strips plus the width, to take care of the meeting rail between the top and bottom sash. A 4'-0"x6'-0" double hung window will require 20 lin. ft. of weather strips for the sides, head and sill and 4 lin. ft. of interlocking material for the meeting rails.

The lineal foot cost of metal weather strip for double hung windows will average as follows in zinc:

Description	Sash Thickness 1⅜"	1¾"	2¼"
Side, head and sill strips	$0.115	$0.14	$0.19
Meeting rail strips	.315	.33	.51

The weather strip for a 4'-0"x6'-0"x1⅜" double hung window would cost 20 x .115 plus 4 x .315 or $3.56. Bronze will run about 75% more.

Labor Installing Metal Weather Strips for Double Hung Windows.—When installing metal weather strips on 1⅜" sash for windows up to 3'-0"x5'-6" in cottages, medium price dwellings, etc., an experienced carpenter should weatherstrip 1 window in ¾ to ⅞-hr. or 9 to 10 windows per 8-hr. day, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	0.9	$.....	$.....	$6.75	$6.08

When installing metal weather strips on 1¾" sash for windows up to 4'-0"x7'-0", an experienced carpenter should complete one window in ⅞ to 1-hr. or 8 to 9 windows per 8-hr. day, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$.....	$.....	$6.75	$6.75

If installed in an occupied building, add ¼-hr. per window.

Installing Metal Weather Strips for Double Hung Windows Glazed with Plate Glass.—When installing metal weather strips on 1¾" or 2¼" sash, glazed with plate glass, for openings up to 4'-0"x7'-0", a carpenter should weatherstrip one window in 1⅛ to 1¼ hrs. or 6 to 7 windows per 8-hr. day, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	1.25	$.....	$.....	$6.75	$8.44

On large double hung windows, such as used in office buildings, hotels, etc., where the windows are glazed with plate glass, a carpenter should weatherstrip one window in 1½ to 1¾ hrs. or about 5 windows per 8-hr. day, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	1.6	$.....	$.....	$6.75	$10.80

If installed in occupied buildings, add ¼ to ½-hr. per window.

Weatherstripping In-Swinging Casement Windows.—Single or double casement windows that swing in require a ¾" wide track strip on the hinged side, running in a groove in the sash. At the top, on the latch side, and where the sash meet (in the case of double casement windows) interlocking hook and flat strips are generally used. A trough strip and a hook strip is generally used at the bottom of the sash.

Material for jambs, head and center stiles, in-swinging casement windows costs 11 to 13 cts. per lin. ft. Brass trough section and interlocking sillstrip, $1.20 per lin. ft.

When estimating the number of lin. ft. of strip required for single casement windows, measure the entire distance around the window, but pricing the sill section separately.

For double casement windows, take the distance around the window, plus the height, which allows for the strip where the two sash meet. A 4'-0"x6'-0" double casement window will require 22 lin. ft. of weather strips for jambs, head and center stiles and 4'-0" of sill section.

Labor Weatherstripping In-Swinging Single Casement Windows.—An experienced carpenter should weatherstrip one single casement window in 1 to 1⅓ hrs. or 6 to 8 windows per 8-hr. day, depending upon the size, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	1.3	$.....	$.....	$6.75	$8.78

If installed in an occupied building, add ¼-hr. per window.

Labor Weatherstripping In-Swinging Double Casement Windows.—When weatherstripping in-swinging double casement windows, an experienced carpenter should weatherstrip one window in 1¾ to 2 hrs. or 4 to 5 windows per 8-hr. day, depending upon the size, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50

If installed in an occupied building, add ¼-hr. per window.

Weatherstripping Out-Swinging Casement Windows.—Out-

swinging single casement windows should have ¾" wide track strip on the hinged side, running in a groove in the sash. At the top, on the latch side and where the sash meet (in the case of double casement sash), interlocking hook and flat strips are required. A heavy sill section with interlocking hook strip is generally used at the bottom of the sash. The material for jambs, heads and center stiles will cost about 11 cts. per lin. ft., while the sill section will cost about 56 cts. per lin. ft.

Labor Weatherstripping Out-Swinging Single Casement Sash.—An experienced carpenter should place weather strips on one single casement sash in ¾ to 1 hr. or 8 to 10 windows per 8-hr. day, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$.....	$.....	$6.75	$6.75

If installed in an occupied building, add ¼-hr. per window.

Labor Weatherstripping Out-Swinging Double Casement Sash.—An experienced carpenter should weatherstrip one double casement window in 1¼ to 1½ hrs. or 5 to 6 windows per 8-hr. day, at the following labor cost per window:

	Hours	Rate	Total	Rate	Total
Carpenter	1.4	$.....	$.....	$6.75	$9.45

If installed in an occupied building, add ¼-hr. per window.

Weather Strips for Single Wood Doors.—Consisting of spring bronze strips for jambs and heads and 1½" interlocking brass threshold for sill.

Door Size Up To	Thick	Price	Door Size Up To	Thick	Price
2'-8"x6'-8"	1⅜"	$6.22	2'-8"x6'-8"	1¾"	$6.84
3'-0"x7'-0"	1⅜"	6.90	3'-0"x7'-0"	1¾"	7.40

If aluminum interlocking thresholds are used instead of brass, deduct $1.75 for 2'-8" openings and $2.00 for 3'-0"x7'-0" openings.

If interlocking zinc is used instead of spring bronze, the interlocking material will cost $1.50 per door additional.

If interlocking bronze is used instead of spring bronze, add $3.00 per door to the above prices.

Extruded aluminum and felt or neoprene sponge 1⅛" long and ¼" thick to be set on stops at heads and jambs runs $0.85 per foot. Extruded aluminum with neoprene gasket 1¼" deep by $\frac{25}{32}$" thick to be set on stops runs $2.20 per foot. A similar gasket for mounting on bottom rail of door runs $1.20 per foot.

A complete extruded aluminum channel with integral drip and vinyl insert at sill runs $1.00 per foot. 6" wide extruded aluminum thresholds for use with above rail strips runs $2.25 per foot. A complete extruded aluminum threshold 3¾" wide by ¾" thick with

integral latch track and interlock and hook stop for mounting on outside of door runs $3.00 per foot complete. A two-piece extruded aluminum with neoprene gasket astragal for surface mounting on double doors runs $2.60 per lineal foot.

A one-piece extruded aluminum and neoprene gasket designed for recessing in meeting rail will run $1.40 per lineal foot. Adjustable two-piece astragals with pile will run $3.50 per foot per each door leaf in extruded aluminum, $4.00 in dull bronze, and $4.80 in polished bronze or dull chrome.

Labor Weatherstripping Single Wood Doors.—An experienced carpenter should weatherstrip one 3'-0"x7'-0"x1¾" door in 1½ to 1¾ hrs. or about 5 doors per 8-hr. day, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	1.6	$.....	$.....	$6.75	$10.80

Where interlocking weather strip is used for head and jambs of doors instead of spring bronze, add ½ to ¾-hr. carpenter time to the time given above.

It will require about 2 hrs. carpenter time to weatherstrip one 2¼" door or about 4 doors per 8-hr. day, at the following labor cost per door:

	Hours	Rate	Total	Rate	Total
Carpenter	2	$.....	$.....	$6.75	$13.50

Where interlocking weather strip is used for head and jambs of doors instead of spring bronze, add ½ to ¾-hr. carpenter time to the time given above.

If installed in an occupied building, add ¼ to ½-hr. per door.

Metal Weatherstripping for French Doors.—The material for weatherstripping double doors or French doors consists of spring bronze strips for jambs and head, spring bronze interlocking strip and zinc threshold for sill. For a door up to 5'-0"x7'-0"-1⅜" thick, the material should cost about $8.00; for a 5'-0"x7'-0"-1¾" door, about $9.00.

If wider thresholds are wanted, see prices given below:

Labor Weatherstripping French Doors.—An experienced carpenter should weatherstrip one pair of 1¾" French doors in 2 to 2½ hrs. or 3 to 4 pair per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	2.3	$.....	$.....	$6.75	$15.53

It will require 2½ to 2¾ hrs. carpenter time to weatherstrip one pair of 2¼" doors or 3 to 3½ pair per 8-hr. day, at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	2.8	$.....	$.....	$6.75	$18.90

If installed in an occupied building, add ¼ to ½-hr. per opening.

Weatherstripping Double Doors.—Where double exterior doors are used for openings up to 5′-0″x7′-0″, using spring bronze weather strip for the head, jambs and between doors, with an interlocking threshold at the bottom of the door, figure 3 to 4 hrs. carpenter time per opening, as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	3.5	$.....	$.....	$6.75	$23.63

If interlocking weather strip is used for the head, jambs and meeting rail, add 1 to 1½ hrs. per opening.

If doors, 2¼″ or thicker are used, add ½ to 1-hr. carpenter time for taking off, handling and rehanging heavy doors.

In-Door-Seals.—A felt strip inserted in the bottom of interior wood doors to prevent draughts and cold on the floor. Costs about $12.00 to $14.00 per door installed.

Weatherstripping Steel Casement Windows.—When weatherstripping steel casement windows with spring aluminum, bronze or stainless steel clamp-on type weatherstripping, it will cost from $7.00 to $9.00 per window for windows 2 lights wide and 3 or 4 lights high, and $8.00 to $10.00 per window for windows 2 lights wide and 5 lights high.

Double casement windows will cost double the above prices.

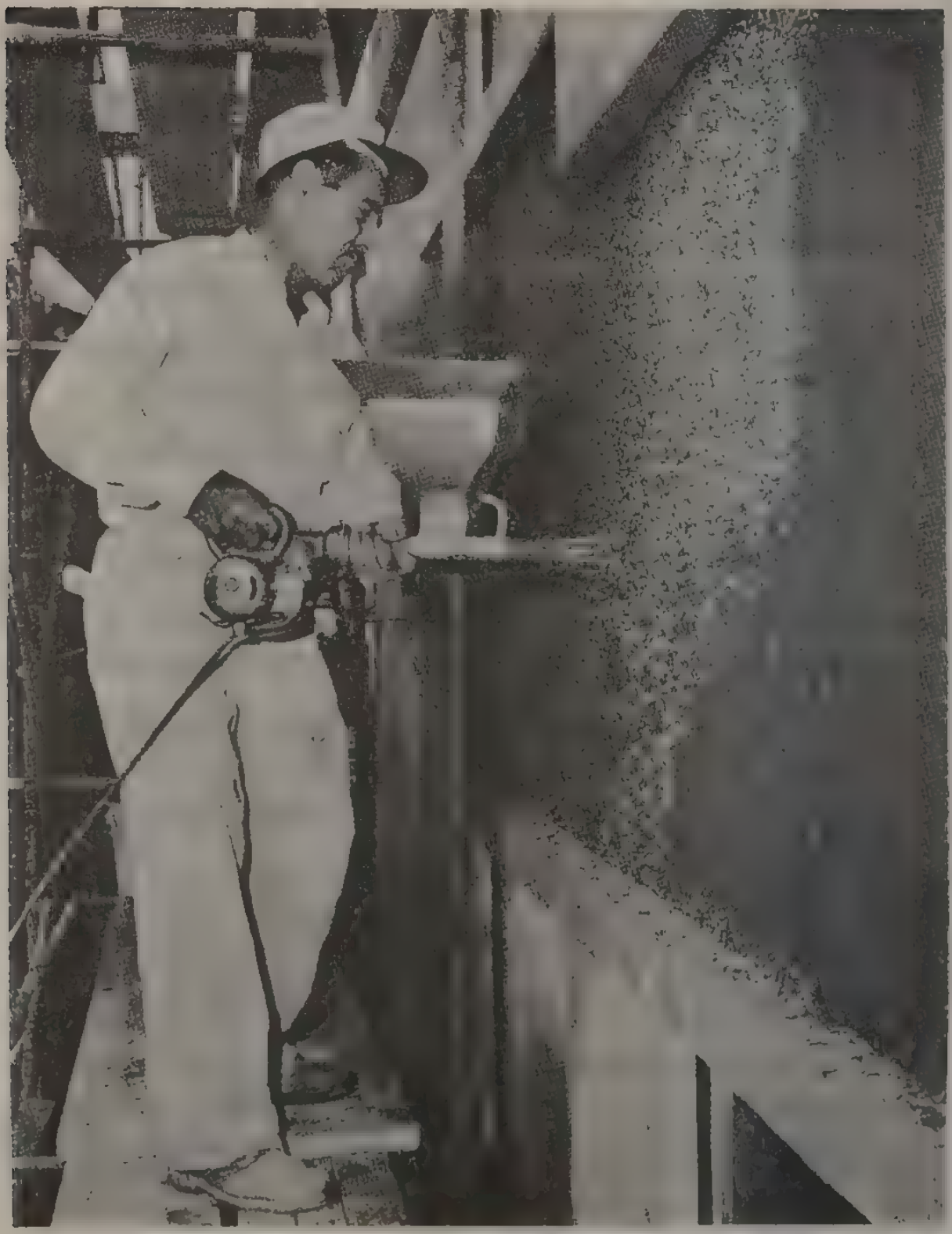
Metal Thresholds

Price per lin. ft. or fraction thereof. Drilled and countersunk, with screws, ready for installation.

Metal	Size	Price per Lin. Ft.	Metal	Size	Price per Lin. Ft.
Brass	1½″x¼″	$1.10	Aluminum	1½″x¼″	$0.43
Brass	3½″x¾″	4.15	Aluminum	3½″x¾″	1.38
Brass	4½″x¾″	4.69	Aluminum	4½″x¾″	1.58
Brass	5 ″x⅞″	5.40	Aluminum	5 ″x⅞″	2.25

All the above thresholds are furnished with interlocking strip.

Caulking Around Door and Window Frames.—For cost of caulking around door and window frames with oakum or mastic caulking compound, refer to "Rough Carpentry."



Machine Application of Fine Stone Finish to Stuccoed Wall

CHAPTER XVIII

GYPSUM AND METAL LATHING; INTERIOR, EXTERIOR AND ORNAMENTAL PLASTERING

Plastering costs vary widely depending upon the kind of materials used and the class of workmanship performed, and the estimator should consider these items carefully before pricing any plastering.

There are two distinct grades of plastering, and the estimator should possess a fair knowledge of the class of work required and estimate accordingly.

The first grade of plastering and the one commonly used on most types of ordinary buildings have the walls rodded and angles and corners fairly straight and true. Work of this class admits of variations and "waves" in the finish up to $\frac{1}{8}$" to $\frac{3}{16}$". This is the regular commercial grade of plastering and on the following pages is headed "Ordinary Work."

The highest grade of work is found only in high grade residences, apartments, hotels, schools, office buildings, court houses, federal government buildings, state capitol buildings, public libraries, etc., where all walls and ceilings together with all interior and exterior angles must be absolutely straight, and plumb and not admit of variations or "waves" exceeding $\frac{1}{32}$" to $\frac{1}{16}$". This is termed "First Grade Workmanship."

Estimating Quantities of Lathing and Plastering.—Lathing and plastering are estimated by the square yard, but the method of deducting openings, etc., varies with the class of work and the individual contractor.

Many plastering contractors make no deductions for door or window openings when estimating new work, while others deduct for one-half of all openings over a certain size.

In some localities, plasterers make a deduction of 7 percent of the gross area to take care of all openings.

Both lathing and plastering are estimated by the sq. yd. which is obtained by multiplying the girth of the room by the height, plus the ceiling area. Example: Obtain the number

of sq. yds. of plastering in a room 12'-0"x18'-0", having 9'-0" ceilings. 18+18+12+12=60 lin. ft. of wall.

60× 9=540 Sq. Ft. Wall Area
12×18=216 Sq. Ft. Ceiling Area
756 Sq. Ft. Area of Walls and Ceiling
756÷9 Sq. Ft. = 84 Sq. Yds.

When measuring spaces under pitched roofs where the opposite walls are not parallel and do not form a rectangular ceiling or where they are not straight or plumb from floor to ceiling and follow the pitch of the roof, the ceiling should be measured from the extreme lengths of wall to wall as if all walls were vertical and the walls should be measured from the floor to the highest point of the ceiling, as if all walls were vertical.

Openings should be measured between grounds and no deductions should be made for openings less than 2'-0" wide, and then only one-half the area of each opening should be deducted. Many plasterers do not make any deductions for openings.

The complete contents of store front openings should be deducted, and the contractor should figure 1'-6" wide for each jamb by the height, when the return or "reveal" is less than 1'-0".

For all beams or girders projecting below ceiling line, allow 1'-0" in width by the total length as an extra for each internal or external angle, in addition to the actual area.

Corner Beads, Moldings, Etc. All corner beads, quirks, rule joints, moldings, casings, cornerites, screeds and other lathing trim accessories necessary to complete a plastering job are measured by the lin. ft., from their longest extension with 1'-0" extra added for each stop or miter.

Plaster Cornices.—Plaster cornices should be measured by the total length of the walls. If the cornices are 1'-0" or less in girth, measurement should be made by the lin. ft., stating the girth of each cornice. If the cornices are over 1'-0" in girth, measurement may be made either by the sq. ft. of exposed face or by the lin. ft., stating the girth of each cornice.

Allow one lin. ft. for each internal miter and 3 lin. ft. for each external miter.

Enriched cornices (cast work) should be measured by the lin. ft. for each enrichment.

Arches, Corbels, Brackets, Ceiling Frieze Plates, Etc.—Arches, corbels, brackets, rings, center pieces, pilasters, columns, cap-

itals, bases, rosettes, pendants, and niches are estimated by the piece. Ceiling frieze plates should be estimated by the sq. ft.

Columns.—Plain plastered columns should be measured by the lin. ft. or by the sq. yd., multiplying the girth by the height.

Cement Wainscot.—Cement wainscot should be measured by the sq. ft. or sq. yd.

Circular or Elliptical Work.—Circular or elliptical work on a small radius should be estimated at double the rate of straight work.

GYPSUM LATH

Gypsum lath is manufactured in 3 types—plain, perforated, and insulating. Each type is made of a core of gypsum with a tough, fibrous surfacing material. For the usual surfaces, either plain

Applying Gypsum Lath to Wood Studs and Joists.*

or perforated gypsum lath is used. Where maximum fire protection is required or desired, perforated gypsum lath should be employed. For insulation against heat and cold, and as a vapor barrier, insulating gypsum lath having an aluminum foil back should be used on the inside face of exterior walls and for top floor ceilings.

Gypsum lath is furnished $\frac{3}{8}$" thick and face dimension is

*Courtesy Gypsum Assoc.

approximately 16"x48", 6 laths per bundle.* Each bundle of laths contains 32 sq. ft. and weighs about 50 lbs. These sizes fit the usual stud or joist spacings without cutting.

Sizes and Weights of Gypsum Lath

Size and Thickness	Wt. Per Sq. Yd.	Approx. Price 1,000 Sq. Ft.
16"x48"x⅜"	14 Lbs.	$52.00
16"x48"x½"	19 Lbs.	60.00

Insulating or aluminum foil backed gypsum lath costs about 2 cents per sq. ft. more than plain lath.

Gypsum lath is also made ½"x16"x48" for framing over 16" on center but not exceeding 24" on center; ⅜"x24"x job length for exterior wall furring with or without foil backing; and ⅜"x16"x96" plain or perforated.

For use in 2" solid studless partitions, gypsum lath is made ½" thick, 24" wide, and in lengths up to 12 ft. These laths are erected with the long dimension vertical.

Nails Required for Gypsum Lath.—Nails shall be 1⅛" long for ⅜" lath and 1¼" long for ½" lath, 13 gauge with $\frac{19}{64}$" flathead and blued. For ⅜" lath on 16" spacing, nails shall be spaced approximately 5" apart using 4 nails per stud and for ½" lath on 24" spacing, nails shall be spaced approximately 4" apart, using 5 nails per framing member. Lath should be butted lightly together. With gaps over ½" wide reinforced with metal lath.

With studs spaced 16" on centers it will require 6 to 7 lbs. of nails per 100 sq. yds. of gypsum lath and with studs spaced 24" on centers it will also require 6 to 7 lbs. per 100 sq. yds. of ½" lath. Lath may also be attached by staples, screws or clips.

Labor Placing Gypsum Lath.—A lather should place 90 to 105 sq. yds. of gypsum lath per 8-hr. day on average work.

Cost of 100 Sq. Yds. of ⅜" Gypsum Lath Applied to Wood Studs or Joists

	Hours	Rate	Total	Rate	Total
900 sq. ft. ⅜" gypsum lath		$.....	$.....	$0.05	$45.00
7 lbs. nails		.....	.....	.20	1.40
Lather	8	.....	.....	6.50	52.00
Cost 100 sq. yds.	8		$.....		$98.40
Cost per sq. yd.					.98

Add for corner beads, cornerites and other accessories required to complete lathing work.

Mechanical Stapling of Gypsum Lath.—Increased production in placing gypsum lath can be gained where labor conditions

*In certain Pacific coast areas, gypsum lath is 16 1/5" wide, 5 pieces or 3 sq. yds. per bundle.

permit the use of air-driven staplers for attaching lath to wood studs or joists.

Air-driven stapler heads, using galvanized frozen staples $\frac{7}{8}$" long with a $\frac{3}{8}$" crown, cost about $150.00 each. Staples cost 80 to 90 cts. per thousand depending upon quantity purchased and are packed 12,000 to the carton. An air compressor able to handle one stapler head will cost about $350.00 and a 2-stapler head capacity machine will cost about $700.00

For this type of attachment, it is general practice to tack lath into place, using 2 nails per piece for wall lath and 4 nails per piece for ceiling lath, until enough area is covered to permit continuous stapling. Attachment is completed by stapling 4" on center to all wood studs or joists. Approximately 3,500 staples and 1-lb. of nails are required per 100 sq. yds. of gypsum lath.

Cost of 100 Sq. Yds. of $\frac{3}{8}$" Gypsum Lath Applied to Wood Studs or Joists Using Air-Driven Staples

	Hours	Rate	Total	Rate	Total
900 sq. ft. $\frac{3}{8}$" gypsum lath..		$.....	$.....	$0.05	$45.00
1 lb. nails		.....	.....	.20	.20
3,500 galv., frozen staples, 17 ga., $\frac{7}{8}$" long with $\frac{3}{8}$" crown		.....	.....	.80	2.80
Machine cost	1.5	.....	.....	.25	.38
Lather	5.3	.....	.....	6.50	34.45
Cost 100 sq. yds.	5.3		$.....		$82.83
Cost per sq. yd			.....		.83

Two (2") Inch Solid Gypsum Long Length Lath and Plaster Partition

A studless, non-load-bearing partition consisting of $\frac{1}{2}$" thick, 24" wide, long length (up to 12'-0") gypsum lath with V'd tongue and groove edges, held vertically in floor and ceiling runners and plastered to $\frac{3}{4}$" grounds each side.

Temporary bracing consists of $\frac{3}{4}$" cold rolled channels horizontally (one channel for heights up to 9'-0" and two channels at the third points for heights up to 12'-0") is required with adequate vertical braces on partitions over 6'-0" long every 6'-0" or fraction thereof during initial plastering stages.

A metal ceiling runner is used for attachment at the ceiling and either a $2\frac{1}{2}$" flush metal base or a routed out wood floor runner may be used at the floor to secure the long sheets of gypsum board lath.

On work of this class it will require 20 to 24 hours lather

Laying Out and Placing Floor Runners for Long Length Gypsum Lath Partitions

time to set and place floor and ceiling runners and gypsum lath for 100 sq. yds. of partition, after the material has been hoisted and placed by laborers, which will average about 4 hrs. per 100 sq. yds.

Cost of 100 Sq. Yds. 2″ Solid Gypsum Long Length Lath and Plaster Partition

(Partition only, not including plastering)

	Hours	Rate	Total	Rate	Total
115 lin. ft. ceiling runner		$.....	$.....	$0.07	$ 8.05
115 lin. ft. 2½″ flush metal base*		.....	.....	.30	34.50
945 sq. ft. ½″ long length gypsum lath		.....	.....	.063	59.54
50 lin. ft. 3″ strip lath and paper backing		.....	.....	.02	1.00
155 lin. ft. temp. bracing channels**		.....	.....	.016**	2.48
100 temp. bracing clips		.....	.....	.0075	.75
Lather	22	.....	.....	6.50	143.00
Labor	4	.....	.....	5.00	20.00
Cost per 100 sq. yds.	26		$.....		$269.32
Cost per sq. yd.			.....		2.69
Cost per sq. ft.			.....		.30

Add for corner beads, cornerites and other accessories required to complete lathing work. Also available are 1″ thick gypsum lath either solid or laminated which reduce the requirements for bracing and grounds.

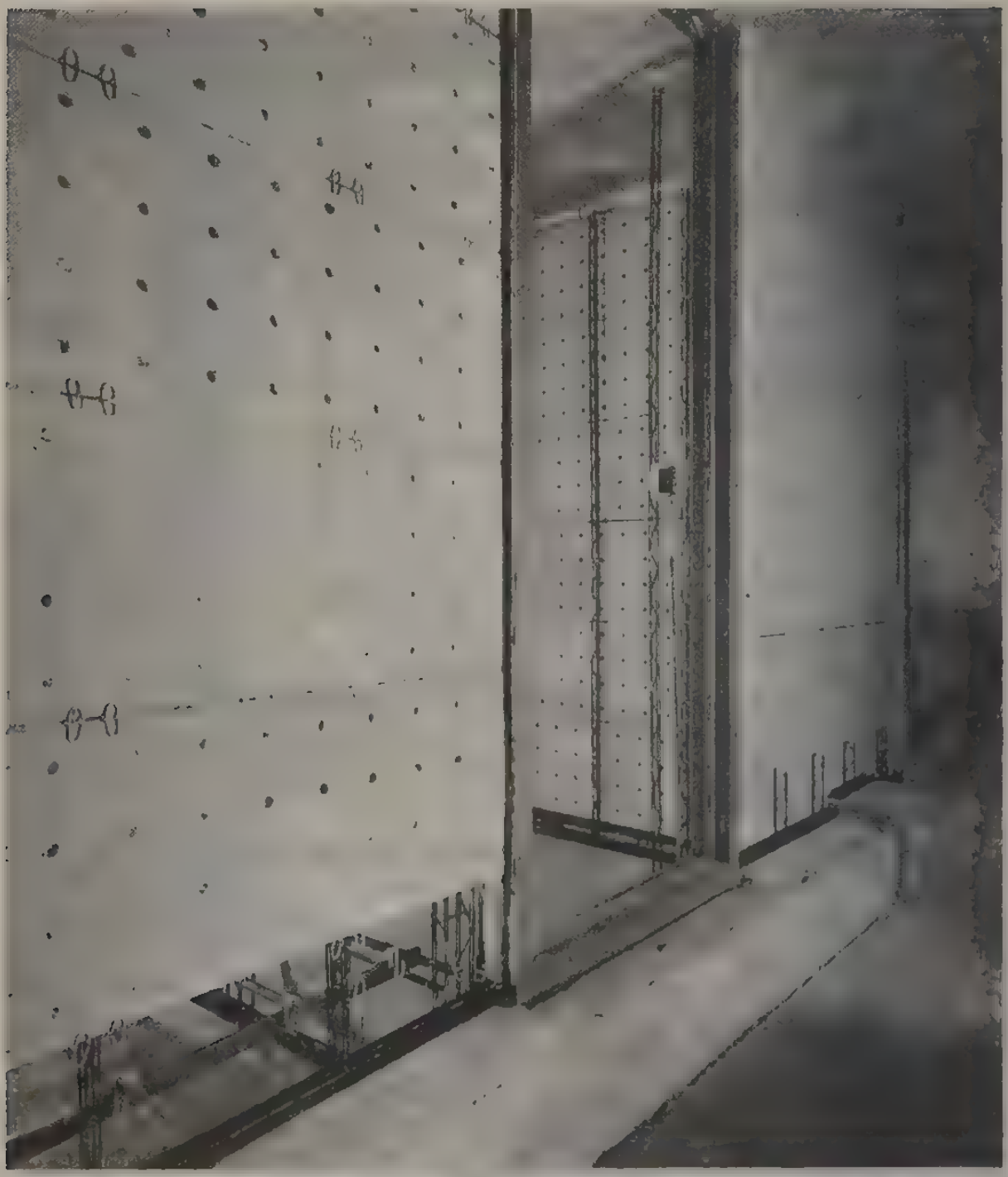
Floating Systems of Attachment of Gypsum Lath.—In order to eliminate the sources of sound transmission in walls and ceilings, the principle of resiliently isolating the interior walls and ceilings from their structural elements (studs and joists) has proven extremely effective as a means of confining the sound at its source. It interposes a shock absorber that reduces the energy transmitted to the structural elements of the building. Interior wall and ceiling finish should be completely and thoroughly isolated from all structural members surrounding the source of sound.

Attachment devices for gypsum lath are designed to isolate the lath from framing members. They are made from sheet metal or wire, and generally include field and corner clips for the attachment to wood, metal furring and masonry.

In addition to reducing sound transmission, the source of plaster cracking is also often eliminated when occasioned by

*Floor runner may be a special wood or steel runner channel at correspondingly lower material and installation cost in carpentry labor, but will require wood base at additional cost.

**115 lin. ft. of horizontal temporary bracing channels, plus five 8-ft. verticals figured on a minimum of 3 re-uses.



Perforated Gypsum Lath on Steel Studs

movement of the structural elements which are stronger than the plastered interior. Floating systems of attachment permit a limited movement of the structural members without imposing undue stresses in the lath and plaster interior.

The spacing of framing members should not exceed 16" o.c. for clip attachments. Plain gypsum lath should be used on ceilings, and either plain or perforated lath may be used on walls.

The additional cost of floating attachments as compared to the

nail-on method usually does not exceed 30 cts. per sq. yd. Approximately 6 resilient clips are required per sq. yd. of lath. Clips cost $40.00 to $50.00 per thousand.

Suspended Gypsum Lath Ceilings.—Suspended gypsum lath ceilings consist of metal hangers, runners and furring channels, which in turn support gypsum lath as a base for plaster, or the adhesive application of acoustical tile.

The hangers, runners and furring channels for ceilings are approximately the same as required for metal lath. Furring channel spacing must not exceed 16". Some fire resistive ratings require 12" spacing. Starter channels along walls should be within 2" of wall. A ½" space should be provided between ends of channels and masonry walls. Each lath is supported transversely under the channels by a long wire clip, with not less than 3 such clips per full length of lath.

Stagger the end joints by starting alternative rows with half lengths of lath, allowing end joints to fall between channels.

Cost of 100 Sq. Yds. Suspended Gypsum Lath Ceilings Using 16"x48"x⅜" Gypsum Lath with Main Runners 3'-0" on Centers and Cross Furring Channels 16" on Centers

	Hours	Rate	Total	Rate	Total
77 pcs. 3/16"x3'-0" hangers, 231'-0"		$.....	$.....	$0.016	$ 3.69
364 lin. ft. 1½" channels		.....	.....	.08	29.12
700 lin. ft. ¾" channels		.....	.....	.04	28.00
945 sq. ft. 16"x48"x⅜" gypsum lath		.....	.....	.05	47.25
500 Brace-tite field clips		.....	.....	.046	23.00
340 Bridjoint clips, B-1		.....	.....	.017	5.78
Lather	20	.....	.....	6.50	130.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.	24		$....		$286.84
Cost per sq. yd.			.....		2.87

The above ceiling has a fire rating of 1 hour. If the job specification calls for a fire resistance rating of two hours, 14 ga. diagonal wire reinforcement must be added below the lath, to obtain a 4 hour rating, 1" 20 ga. galvanized 1" hex wire mesh must be added. All the above ratings are dependent on the type of floor construction above.

Hollow Steel Stud Partitions Using Gypsum Lath as a Plaster Base.—A non-load-bearing partition of trussed steel studs, track and shoes to which gypsum lath is applied to both sides by means of metal clips, nailing or stapling.

The construction is similar to that described on the following pages under "Hollow Steel Stud Non-Bearing Partitions" except that gypsum lath is applied to the studs by means of special metal clips and the studs are spaced 16" on centers to receive the 16"x48" gypsum lath.

Cost of 100 Sq. Yds. of Hollow Steel Stud Non-Bearing Plastered Partitions Using Gypsum Lath on Both Sides of Partitions, Studs 16" on Centers, Ready to Receive Plaster

	Hours	Rate	Total	Rate	Total
105 lin. ft. top track		$.....	$.....	$0.101*	$ 10.61
105 lin. ft. bottom track		.....	.....	.101*	10.61
76 9'-0" studs, use 750 lin. ft.**		.....	.....	.101*	75.75
1,900 sq. ft. gypsum lath		.....	.....	.05	95.00
1,000 Trus-Lok field clips		.....	.....	.018	18.00
680 Bridjoint clips		.....	.....	.017	11.56
Lather	28	.....	.....	6.50	182.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.	32		$.....		$423.53
Cost per sq. yd.					4.24

Add for corner beads, cornerites and other accessories required to complete lathing work.

Gypsum lath is also used for exterior wall furring and column fireproofing. Special framing support systems are manufactured for this. Foil backed lath may be used for exterior walls.

WOOD LATH

Wood lath for plastering is almost a thing of the past. Gypsum lath and metal lath are commonly used.

The following data is included for that one in a thousand job where wood lath may be used, for patching in remodeling work.

Wood lath should be estimated by the sq. yd. Inasmuch as it is customary to deduct only one-half the area of openings, it is not necessary to add any allowance for waste. When placing wood lath it is customary to allow $\frac{3}{8}$" between each lath for a plaster key.

A standard wood lath is $1\frac{1}{2}$" wide and 48" long, as follows:

Size of Lath	No. Req'd. 100 Sq. Yds.
$1\frac{1}{2}$"x48"	1,425—1,450

Labor Placing Wood Lath.—A lather should place 1,400 to 1,600 $1\frac{1}{2}$"x48" wood lath, (95 to 110 sq. yds.) per 8-hr. day.

*Based on $2\frac{1}{2}$". $3\frac{1}{4}$" costs $0.107; 4", $0.120; 6", $0.153.
**Allowance made for opening framing.

METAL LATH AND FURRING

Where metal lath is used as a plaster base in partition work, it may be nailed or stapled to wood or steel studs, nailed to masonry, or wire-tied to steel channels and prefabricated steel studs. It may also be used without studs or back-up when attached to floor and ceiling runners and temporarily braced during application and curing of first coat of plaster. Where used as a plaster base in ceiling work, it may be nailed to wood joists, wire-tied to various metal support systems either in contact with or suspended from the building structure, or wire-tied directly to the bottom chords of steel joists. It may also be attached directly to the underside of reinforced concrete floors or joists by means of attachments previously embedded in the concrete.

In addition to its utility as a plaster base, metal lath is also used to reinforce plaster applied to other surfaces. Prefabricated, right-angled strips of metal lath are attached to masonry or other rigid plaster bases, prior to plastering, at the interior angles formed by intersecting walls and along the junction of walls and ceilings. Flat strips of metal lath are attached to solid plaster bases to reinforce the joints in such bases, or to bridge potential crack lines at the corners of door and window openings. A stuccoed unit masonry wall may be reinforced against wind moments and overturning by means of self-furring or dimpled metal lath, nailed to the block and firmly anchored to the building foundation. Rib metal lath is often used as a combination form and reinforcement for concrete floor and roof decks, usually in constructions of open web steel joists.

Metal lath is used in the individual fireproofing of beams and columns. It may be adapted to decorative shapes for cornices, coves, curved walls, convoluted ceilings and various acoustic shapes such as inverted pyramids. In specialty classifications, it is used to form the membrane of hyperbolic paraboloids, or the web section of concrete beams and girders.

Metal Lath Construction.—The costs of metal lathing will vary according to the complexities of the work in which it is used, the size of the rooms, the height above floors, and the method of attachment. In the sections which follow, attempt is made to cover only the type of lathing which is usual and normal in building construction.

Materials

A number of metal and wire laths, and welded wire fabrics is available to suit the various conditions which might be encountered in building construction. In general, there are sheets of slitted and expanded metal, or perforated metal, commonly

called metal laths; rolls of netting formed of 19 ga. wire woven into a pattern which provides 2½ strands per inch, commonly called wire laths; and sheets of open mesh laths formed of strands of 16 gauge wire welded at right angles to one another and spaced 2″ apart, commonly called welded wire fabric. Laths may be of galvanized metal or painted with a rust-inhibitive paint. Some metal laths and all welded wire fabrics are available with a paper backing. Also, some laths may be obtained with a backing of aluminum foil laminated with paper. The backings sometimes perform useful functions insofar as utility and plastering are concerned, but many such laths are often more difficult to install.

Expanded metal lath can be either flat dimpled (self-furring), or ribbed. The flat expanded type is classed as small mesh, having approximately 1000 openings per square foot. The perforated metal lath, commonly called sheet lath, is fabricated either with furring indentations or with channel-shaped ribs. The openings in sheet lath and in rib lath are classified as small. Although they are somewhat larger than those of the expanded metal laths, they are separated by larger areas of unperforated metal. Stucco mesh has diamond-shaped openings which are approximately 1½″x3″. Wire laths are flat when installed and the openings are classified as of medium size. The welded wire fabrics are either flat or, in the crimped, self-furring variety, all the wires laying in one direction are bent approximately ¼″ out of a flat plane, at their intersection with every third wire lying in the other direction.

Installation Procedures

Rather rigid industry standards govern the installation of metal laths, particularly with respect to ceiling work. Complete specifications are prepared by associations of the manufacturers, by individual manufacturers, or by sectional committees of the American Standards Association. The building construction estimator will require a brief outline of the critical factors of installation in order to derive a realistic estimate of costs.

Spans of Lath.—In all work except where the laths are supported by solid surfaces, and except in the case of studless solid partitions, the weight of metal lath must be suitable to the distance between studs, joists or other supporting members. The laths are attached to these members by nails, wire-ties, staples or clips, at intervals not exceeding 6″. The following chart gives maximum spans, or distance between supports for various weights of metal and wire laths and welded wire fabric.

Type of Lath	Maximum Allowable Spacing of Supports in Inches					
	Min. Wt. Lath Lbs. per Sq. Yd.	Vertical Supports			Horizontal Supports	
		Wood	Metal Solid Partit.	Others	Wood or Concrete	Metal
Flat Expanded Metal Lath	2.5	16	16	12	0	0
Flat Rib Metal Lath	3.4	16	16	16	16	13½
⅜" Rib Metal Lath	2.75	16	16	16	16	12
Sheet Lath*	3.4	19	24	19	19	19
Wire Lath	4.0	24	..	24	24	24
V-Stiffened Wire Lath	4.5	24	..	24	24	24
Wire Fabric	2.48	16	16	16	13½	13½
	3.3	24	24	24	19	19
	..	16	0	16	16	16

*Used in studless solid partitions.

Laps of Lath.—Industry standards require overlapping at ends and sides of sheets of lath. Most sheets are manufactured slightly larger than nominal size and the estimator need not allow extra quantities on this account. A few extra ties are required in all laps: one between each supporting member and, where laps of the ends of sheets fall between supports, such laps should be laced with tie wire. These extra ties are considered part of normal lathing work and no extra allowance need be made for them.

Attachment of Lath.*—Nail-on attachment of metal lath to horizontal or sloping surfaces (ceilings and soffits) requires the use of No. 11 ga. barbed, galvanized roofing nails with a head diameter of $\frac{7}{16}$". The length of such nails must permit a minimum penetration into the wood of 1⅜". In nail-on attachment of metal lath to vertical surfaces (walls and partitions) 4d common nails are permitted. They should penetrate the wood at least ¾" however, and the remainder should be bent over the strands of lath. Also, in vertical work, 1" long roofing nails with a head diameter of $\frac{7}{16}$" are permitted. They are driven home without crushing the strands of metal. In direct attachment to masonry, concrete stub nails with ⅜" flat heads are generally used.

Tie-on attachment of metal lath is generally done with 18 ga. galvanized annealed wire, a strand of wire passing through the

*Wire sizes specified are U. S. Steel Wire Gauge. These are the same as the older Washburn and Moen gauges.

mesh, around the support member, and back through the mesh with the two ends twisted together approximately three turns. This operation is more difficult for the lather when paper or foil-backed lath is being used, unless adequate openings in the backing have been provided. Therefore, when estimating hand tying of lath having heavy backing, a reduction in labor productivity should be allowed. In certain cases 18 ga. tie wire is not permitted. Where metal lath is attached directly to structural elements of the building, such as concrete slabs or joists or the bottom chord of open web steel joists, wire of heavier gauge, or more than one loop of 18 ga. wire, is required (16 ga. or 2-18 ga. for steel joist work; 14 ga. twisted or 10 ga. bent over for concrete work). The extra difficulty of twisting and cutting the heavier gauge wires has been considered in the productivity rates suggested below. Any extra labor costs incurred by direct attachment of metal lath is usually offset by a savings in supporting members or framing.

Special devices for attachment of laths are permitted, where they develop a fastening of strength equal to the accepted standards. Such devices often result in noticeable labor savings but the estimator should not neglect to adjust his material costs as necessary.

Horizontal Support Systems.—Horizontal supports for metal lath fall under the general classifications of contact systems, where the lath is fastened in direct contact with the structural elements of the building, furred systems, or suspended systems. In both of the latter systems, the laths are attached in the usual manner to a framework of pencil rods or channel shapes which have been fastened directly to, or suspended from, structural elements of the building. In a furred system, the channels or pencil rod furring are attached to the structural elements of the building, by means of 16 ga. wire saddle ties—in open web steel joist construction, or by 18 ga. wire saddle ties supported by nails driven in or through wood joists. The forming of saddle ties is considered normal lathing work and the productivity rates suggested below contemplate this type of tying.

In a suspended system, the channels or pencil rods to which the lath is attached, are called cross-furring. These members are saddle-tied with 16 ga. wire to the underside of an intersecting framework of heavier channels, which have been hung from the structural elements of the building by means of wire, rod or flat steel hangers. Wire hangers and rods are saddle tied around these support channels, which are called main runners, and flats may be welded or bolted to them.

A combination of the furred and suspended systems is usually found where furring members are installed in contact with concrete joists. The furring members which support the lath are in contact with the bottoms of the joists, but they are supported by transverse channels, or runners, which are suspended between and run parallel to the joists. The furring members are saddle-tied wth 16 ga. wire to the runners, and the runners are suspended by means of 10 ga. wire hangers embedded in the slab above. The wire hangers are saddle-tied to the runners.

In contact, furred or suspended systems, the lath must be supported at spans not exceeding those given in the table of maximum spans, above. In furred and suspended systems, all pencil rods and channels are limited as to distance between supports and center to center spacing, and—in suspended systems—the size of each hanger is dependent upon the area of ceiling which it supports. The following tables list the usual elements and arrangements to be found in furred and suspended ceilings.

Hanger Sizes for Suspended Ceilings

Ceiling Area, SF Max.	Hanger Size Min.	Hangers for Supporting up to 25 SF Ceiling
8	12 ga. wire	6 ga. wire
12	10 ga. wire	5 ga. wire
12½	9 ga. wire	3/16" rod
16	8 ga. wire	7/32" rod
17½	7 ga. wire	1/4" rod

Ceiling Area, SF Max.	Hangers for Supporting up to 25 SF Ceiling
8	1 "x3/16" flat
12	1¼"x 1/8" flat
12½	1¼"x3/16" flat
16	1½"x 1/8" flat
17½	1½"x3/16" flat

*All wire hangers should be galvanized steel, all flat and rod hangers should be coated with rust-inhibitive paint.

Spans and Spacing for Main Runners in Suspended Ceilings

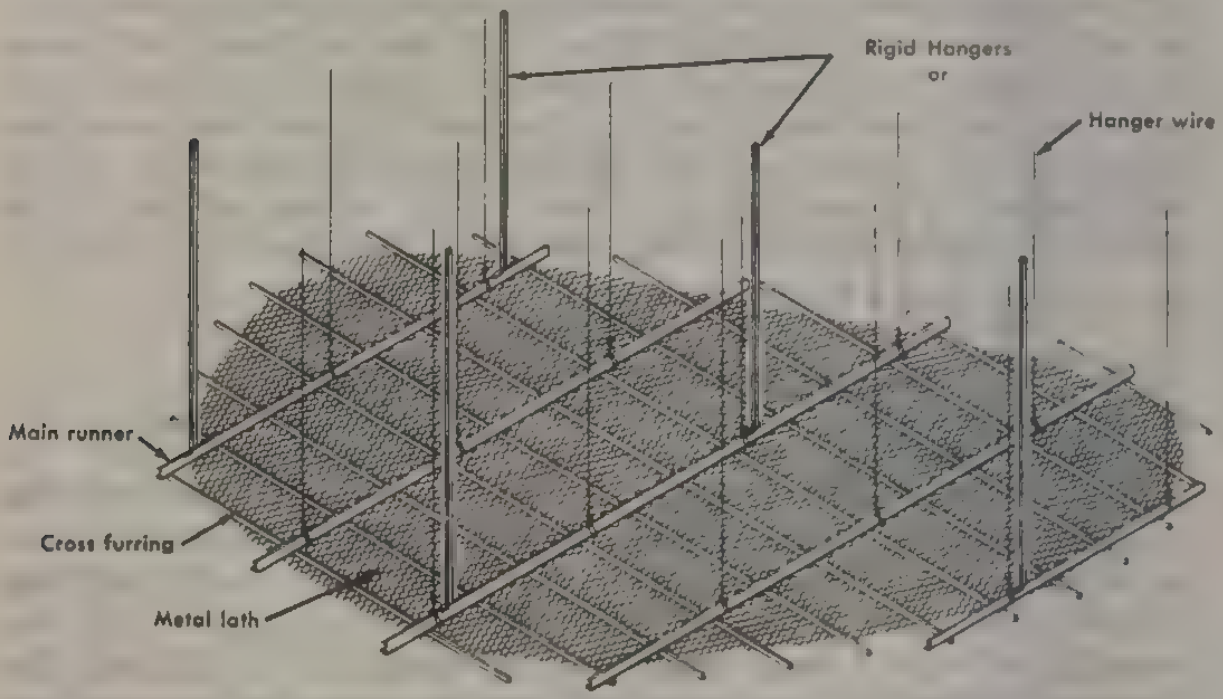
Min. Size and Type	Max. Span Between Hangers or Supports	Max. CtoC Spacing of Runners
¾" channel, .3 lb.	3'-0"	2'-4"*
¾" channel, .3 lb.	2'-6"	2'-6"
¾" channel, .3 lb.	2'-0"	3'-0"
1½" channel, .475 lb.	5'-0"	2'-0"
1½" channel, .475 lb.	4'-0"	3'-0"
1½" channel, .475 lb.	3'-6"	3'-6"
1½" channel, .475 lb.	3'-0"	4'-0"
2 " channel, .59 lb.	7'-0"	2'-0"
2 " channel, .59 lb.	5'-0"	3'-6"
2 " channel, .59 lb.	4'-6"	4'-0"

All weights of channel are for cold-rolled members.
*This spacing for runner channels supporting furring members against concrete joists, only.

Spans and Spacing for Cross Furring

Min. Size and Type	Max. Span Between Runners or Supports	Max. CtoC Spacing of Cross Furring
3/8" pencil rod	2'-6"	12"
3/8" pencil rod	2'-0"	19"
1/4" channel, .3 lb.	4'-0"	16"
1/4" channel, .3 lb.	3'-6"	19"
1/4" channel, .3 lb.	3'-0"	24"

All weights of channel are for cold-rolled members.



Details of Suspended Ceiling*

In most horizontal work, the laths, framing members, hangers and inserts are installed in the usual manner. The estimator need not look for obscure items of extra material and labor. However, he should look for the presence of large ducts which might require additional framing or hangers, not detailed on the drawings. He should allow for hung or tied supports at the perimeter of rooms and not plan to set channels into wall pockets. The estimator's check list of materials should usually contain allowances for lath, furring channels, carrying channels, tie wire, hanger wire, nails, special inserts if any, corner reinforcing, and accessory items, if required, such as expansion bead or casing bead.

Vertical Support Systems.—Metal lath may be used in a number of wall and partition framing systems. A generalized classi-

*Metal Lath Manufacturers Association.

fication would include hollow walls and partitions, solid plaster partitions, vertical furring and wall cladding. Hollow assemblies may have either metal or wood studs. The metal studs are generally used where non-combustible construction is required, where concealed horizontal pipe must be accommodated, or where sound resistive qualities are needed. Although the majority of such studs are rated as non-load-bearing, because they are fabricated from light-gauge steel, or rod, tests of completed walls have indicated surprising load carrying capacity and resistance to horizontal impact.

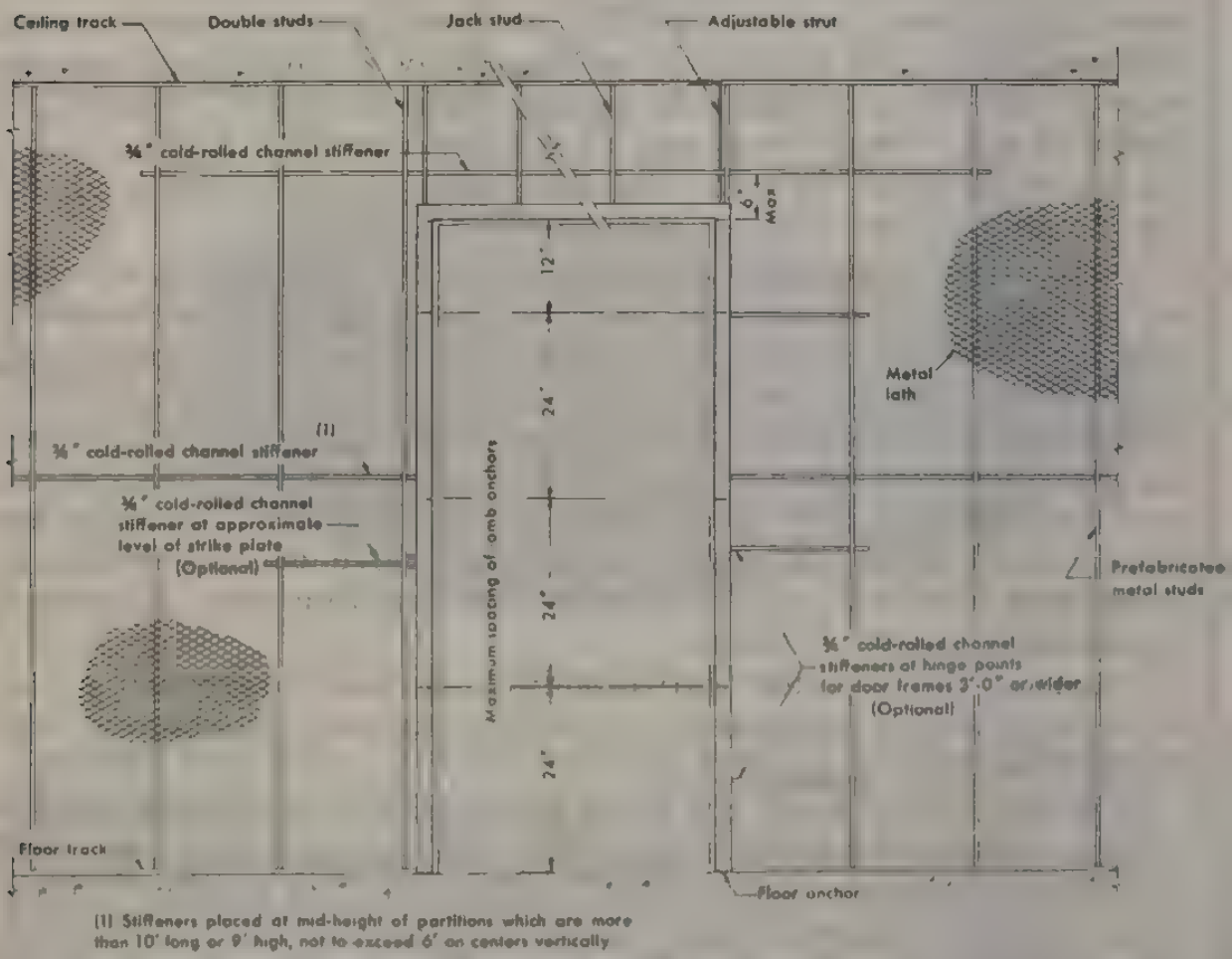
Thin solid plaster partitions may be formed over a core of metal lath alone, or an assembly of metal lath and metal studs. The studless solid partitions are generally 2″ thick and may be as much as 10′ in height. The solid partitions with ¾″ cold-rolled channels may range between 1½″ thickness and 8½′ height to 2½″ thickness and 16′ height. Heavier channels may be used for thicker and higher solid partitions.

Vertical, or wall, furring systems may be braced from exterior walls, pilasters, or interior columns, or may be free-standing. Their utility is sometimes decorative, at other times functional. Functional aspects include concealment, fireproofing, acoustic treatment, condensation and temperature control. The lathing installation is essentially that of a partition with studs, lathed on one side only. However, horizontally-placed ¾″ channels are required for stiffening steel studs, and above certain heights—dependent upon size of these studs—the framing must be braced from the structure behind.

Exterior and interior wall claddings include overcoating (remodelling work), decorative surfacing, acoustic surfacing, and reinforcement.

In most vertical work, the laths are applied in the usual manner and the estimator need not look for hidden items of extra material and labor. However, a few unusual operations are worthy of note. In erection of studless solid partitions, the laths must be braced temporarily until first, or scratch coat of plaster has set. In erection of sound resistive partitions, various systems for separating the components of the partition may be encountered. These might include resilient clips and pencil rod furring between the metal studs and metal lath, staggered stud arrangements which require double the normal number of studs, or double rows of small studs with short pieces of cross-tie channels between them. Note also that most soundproofing partitions extend up to the structure itself, and are not terminated at the level of a suspended ceiling or the bottoms of joists. In wall

cladding work, some of the more dense back-up materials, such as reinforced concrete or old brick, may be difficult to penetrate with nails, thus slowing the progress of the lather. In certain areas of the country, the exterior walls of stuccoed dwellings may be constructed without sheathing. In this style of erection, known as line wire construction, the lathing work sometimes includes installation of 18 ga. wires, stretched taut completely around the building, and fastened securely to the studs at 6″ intervals vertically. This operation is generally performed only when woven wire or stucco mesh is the plaster base.


Ceiling track
Double studs
Jack stud
Adjustable strut
¾" cold-rolled channel stiffener
6" Max
12"
24"
24"
24"
Metal lath
(1)
¾" cold-rolled channel stiffener
¾" cold-rolled channel stiffener at approximate level of strike plate (Optional)
Maximum spacing of omb anchors
Prefabricated metal studs
¾" cold-rolled channel stiffeners at hinge points for door frames 3'-0" or wider (Optional)
Floor track
Floor anchor
(1) Stiffeners placed at mid-height of partitions which are more than 10' long or 9' high, not to exceed 6' on centers vertically

Partition Framing At Door Openings*

The estimator's check list of materials for vertical work should usually contain allowances for lath, studs if any, four shoes for each prefabricated metal stud (2 top and 2 bottom), ceiling and floor tracks for holding studs and shoes, nails for attachment of either the tracks or bent-over ends (of small studs) to ceiling and floor, nails for attachment of lath to wood or solid back-up, wire for tying lath and shoes to studs, and shoes to tracks, if

*Metal Lath Manufacturers Association.

required, metal base or screeds, if any, and accessory items such as corner, casing or expansion beads, and picture molds, if required. In estimating requirements for studs, allow for double-studding at door frames where necessary and, where splicing is required, allow for an 8" lap and double wire-tying.

Installation—Labor

Nail-On Attachment of Metal Lath.—For either horizontal or vertical work, the lather should apply 160 sq. yds. of metal lath per 8-hr. day, depending on size of rooms.

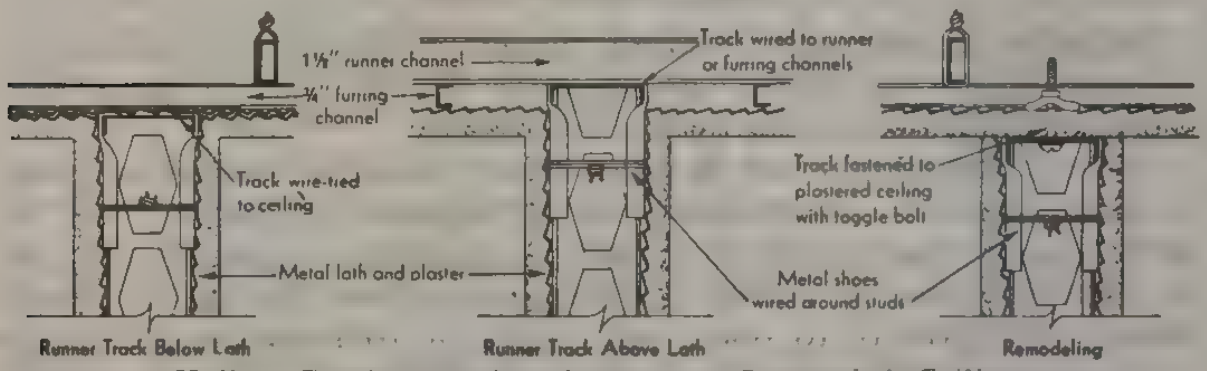
Tie-On Attachment of Metal Lath.—Uusually the actual tying of metal lath is not isolated as a separate operation, for the lather must also install the studs or channels to which the lath is tied. However, in contact ceiling work where the lath is sometimes tied directly to open web joists or to hangers previously embedded in concrete, the lather should apply 100 sq. yds. of metal lath per 8-hr. day.

Furred and Suspended Horizontal Systems.—In furred ceiling work, including installation of furring members and lath but not including drilling for and placement of inserts in concrete, the lather should apply 50 sq. yds. per 8-hr. day. In suspended ceiling work, including installation of wire and rod hangers (but not concrete inserts for hangers), main runner channels, cross furring channels, and lath, the lather should apply 40 sq. yds. per 8-hr. day. Where strap hangers are used (bolted construction), the lather should complete 30 sq. yds. per 8-hr. day. In drilling concrete and placing hanger inserts, the lather should cover 25 sq. yds. of area per 8-hr. day. In closets, toilet rooms and other small spaces, a lather may complete only 30 sq. yds. of suspended ceilings per 8-hr. day.

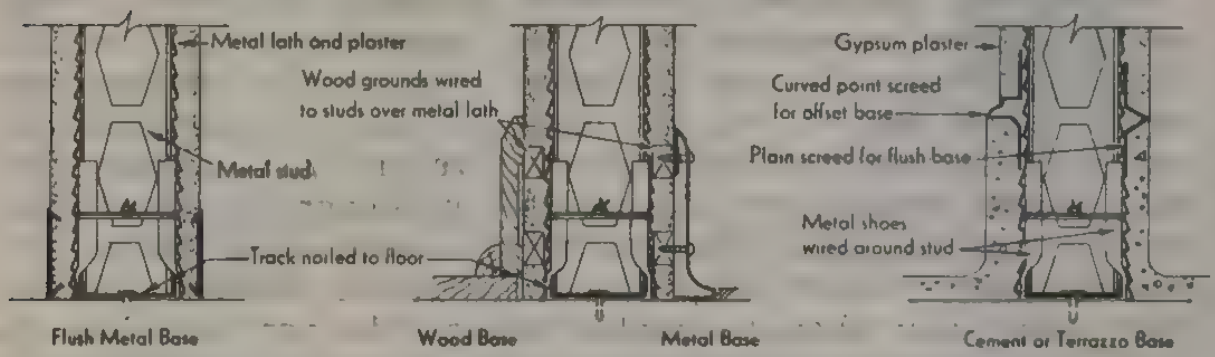
Beam Fireproofing.—In furring and lathing around structural beams, the lather should complete 9 lin. ft. of beam per hour.

Vertical Systems Other Than Nail-On Work: Hollow Partitions.—In hollow partition work, not including sound-resistive construction, a lather should install top and bottom tracks, tie shoes on studs, tie studs and shoes to tracks, apply lath, and complete 30 sq. yds. of partition per 8-hr. day. In 100 sq. yds. of such partitions, approximately 16 man-hours are required to install runners and studs and the attachment of two surfaces of lath should require approximately 11 man-hours. Another version of the steel stud hollow partition (using a framework of $\frac{3}{4}$" cold rolled channels) requires slightly more labor for installation. In this work the lather must erect two walls and tie them together. Productivity to be expected is between 24 and 28 sq.

yds. per 8-hr. day. For estimating sound-resistive hollow partitions with prefabricated steel studs, add 5 man-hours per 100 sq. yds. to cover installation of resilient clips and pencil rods. No extra allowance need be made in the case of hollow partitions with double rows of ¾" channels.


1½" runner channel
¾" furring channel
Track wire-tied to ceiling
Metal lath and plaster
Track wired to runner or furring channels
Track fastened to plastered ceiling with toggle bolt
Metal shoes wired around studs
Runner Track Below Lath
Runner Track Above Lath
Remodeling

Hollow Partitions: Attachments to Suspended Ceilings

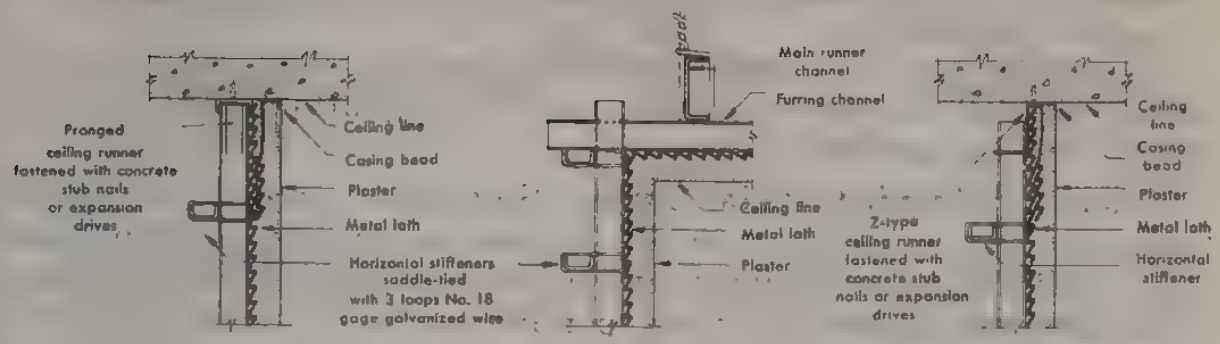


Hollow Partitions: Attachments to Floor*

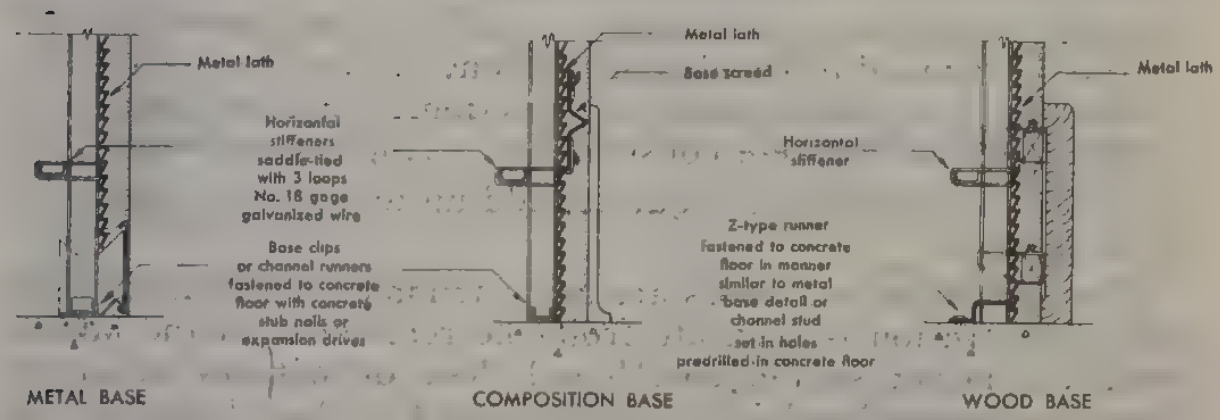
Vertical Systems, Solid Partitions and Vertical Furring.—In erecting solid partitions with ¾" cold rolled channels, a lather should complete 22 sq. yds. per 8-hr. day, depending on spacing of channels and method of attaching channels at floor and ceiling. Studless solid partitions should be erected at the rate 27 sq. yds. per 8-hr. day. Labor savings are realized in the studless system due to elimination of wire tying the lath to channel studs. Vertical furring systems should generally be erected at the same rate as solid partitions with channel studs. However, where wall braces are required, add 4 hrs. per 100 sq. yds.

Vertical Systems, Wall Cladding.—In overcoating work, and in other direct-applied lath attachments, a lather should nail metal lath to surfaces of wood and concrete block at the same rate as for nail-on work to wood studs and joists. Lathing should

*Metal Lath Manufacturers Association.



Details At Ceiling


Metal lath
Horizontal stiffeners saddle-tied with 3 loops No. 18 gage galvanized wire
Base clips or channel runners fastened to concrete floor with concrete stub nails or expansion drives
METAL BASE
Metal lath
Base screed
Horizontal stiffener
Z-type runner fastened to concrete floor in manner similar to metal base detail or channel stud set in holes predrilled in concrete floor
COMPOSITION BASE
Metal lath
WOOD BASE

Floor Attachments*

*Metal Lath Manufacturers Association.

proceed at the rate of 160 sq. yds. per 8-hr. day. In attachment to old brick or reinforced concrete, however, a lather should be expected to complete only 125 sq. yds. per 8-hr. day.

Accessories.—Many metal lathing accessories are available for a variety of functional or trimming purposes. Only a few of the more common items are covered herein. The labor rates given below for erection of some of the functional accessories are inclusive of items of work covered as part of the total assembly. The estimator should, therefore, use the highest productivity rate for erection of an entire assembly, when he lists these functional accessories as separate items. For example: installation of metal base sometimes includes layout of partition and attachment of clips to floor—items of work which are also contemplated in erection of some partition types.

Flush Metal Base.—Double for solid partitions—including layout of partition, attachment of clips to floor, cutting and fitting, attachment of side plates: 5 hrs. per 100 lin. ft. of partition.

Single for masonry trim—including drilling for and setting masonry clips, cutting and fitting, attachment of side plates: 3 hrs. per 100 lin. ft.

Single for wall furring—including layout of furring, attachment of clips to floor, cutting and fitting, attachment of side plates: 4 hrs. per 100 lin. ft.

Flush or Applied Metal Base.—Single for snap-on to metal studs or for screwing to wood grounds—including cutting and fitting, attaching side plates, and attaching clips to studs, but not including wood grounds: 3 hrs. per 100 lin. ft

Beads and Molding, including corner and bullnose beads, picture molds, base screeds, casing bead (except when used for door and window trim), and expansion bead (except when lath and/or framing is severed beneath line of bead).

wired or stapled to lath bases .....2½ hrs. per 100 lin. ft.
nailed or stapled to wood construction...2 hrs. per 100 lin. ft.
nailed to brick, tile or block construction.3 hrs. per 100 lin. ft.
stub-nailed to concrete construction ....3½ hrs. per 100 lin. ft.

If on-the-job mitering is required, add up to ½ hr. per 100 lin. ft. to above rates.

When windows and doors are being trimmed with casing bead, and the operation is separate from the remainder of the lathing work, the lather should complete 1 door or window per hour. When expansion bead is to be installed to a lath base and the base is to be severed beneath the line of bead, add 3 hrs. per 100 lin. ft. for cutting lath.

Cornerite and Stripite, placed in interior wall angles and at junctions of walls and ceilings where adjoining constructions are of rigid lath or masonry, and installed along the joints in non-metallic plaster bases, should be placed at the rate of 500 lin. ft. per 8-hr. day, depending upon whether material is applied in isolated, or repetitious patterns.

Cost of 100 Sq. Yds. of 3.4 Lb. Diamond Mesh Metal Lath Applied to Wood Studs or Joists @ 16″ O.C., Ready to Receive Plaster

	Hours	Rate	Total	Rate	Total
105 sq. yds. diamond mesh		$.....	$.....	$0.60	$63.00
9 lbs. 1½″ roofing nails.....		.....	.....	.19	1.71
Lather	5	.....	.....	6.50	32.50
Cost 100 sq. yds.	5		$.....		$97.21
Cost per sq. yd.....			.....		.97

Cost of 100 Sq. Yds. of 3.4 Lb. ⅜" Rib Metal Lath Applied to Wood Studs or Joists @ 24" O.C., Ready to Receive Plaster

	Hours	Rate	Total	Rate	Total
105 sq. yds. ⅜" rib metal lath		$.....	$.....	$0.75	$ 78.75
6 lbs. 1½" roofing nails.....		.....	.....	.19	1.14
Lather	3.5	.....	.....	6.50	22.75
Cost 100 sq. yds.....	3.5		$.....		$102.64
Cost per sq. yd.....					1.03

Cost of 100 Sq. Yds. of 3.4 Lb. ⅜" Rib Metal Lath Applied Directly to Ties Embedded in Concrete or to Steel Joists at 24" on Centers

	Hours	Rate	Total	Rate	Total
105 sq. yds. ⅜" rib metal lath		$.....	$.....	$0.75	$ 78.75
15 lbs. 18 ga. tie wire.....		.....	.....	.22	3.30
Lather*	8	.....	.....	6.50	52.00
Cost 100 sq. yds.....	8		$.....		$134.05
Cost per sq. yd.....			.....		1.34

Cost of 100 Sq. Yds. of Furred Ceiling Using 3.4 Lb. Flat Rib Metal Lath Applied to ⅜" Pencil Rods 19" on Centers Tied to Structure at 2 Ft. Intervals

	Hours	Rate	Total	Rate	Total
105 sq. yds. flat rib metal lath		$.....	$.....	$0.75	$ 78.75
660 lin. ft. ⅜" pencil rods..		.....	.....	.18	118.80
6 lbs. 18 ga. tie wire (lath to rods)			.....	.32	1.92
2 lbs. 16 ga. wire for splicing rods.....				.30	.60
4 lbs. 16 ga. wire for attaching rods		.....	.....	.30	1.20
Lather*	16	.....	.....	6.50	104.00
Cost 100 sq. yds.....	16		$.....		$305.27
Cost per sq. yd.....			.....		3.05

* Lather hours listed are for attachment of lath only. For concrete joist construction, add for placing wire in forms before pour; or, if necessary to drill holes in concrete.

Cost of 100 Sq. Yds. Suspended Metal Lath Ceiling Using 3.4 Lb. ⅜" Rib Metal Lath With Furring Channels 24" on Centers Runner Channels 36" on Centers, Hangers 48" on Centers

	Hours	Rate	Total	Rate	Total
100-9 ga. x 3'-0" hangers 300'-0" or 19 lbs.		$.....	$.....	$0.25	$ 4.75
345 lin. ft. 1½" c.r. channels		.....	.....	.078	26.91
490 lin. ft. ¾" c.r. channels		.....	.....	.052	25.48
3 lbs. 16 ga. wire		.....	.....	.30	.90
105 sq. yds. ⅜" rib metal lath		.....	.....	.75	78.75
5 lbs. 18 ga. wire		.....	.....	.32	1.60
Lather*	20	.....	.....	6.50	130.00
Cost per 100 sq. yds.	20		$.....		$268.39
Cost per sq. yd.			.....		2.68

*For erection under concrete, add for placing hangers in forms before pour; or, if necessary to drill holes in concrete or tile, and place inserts.

Cost of 100 Sq. Yds. Suspended Metal Lath Ceiling Using 3.4 Lb. Diamond Mesh Metal Lath With Furring Channels 13½" on Centers, Runner Channels 48" on Centers, Hangers 48" on Centers

	Hours	Rate	Total	Rate	Total
85-8 ga. x 3'-0" hangers 255'-0" or 19 lbs.		$.....	$.....	$0.26	$ 4.94
280 lin. ft. 1½" c.r. channels		.....	.....	.078	21.84
850 lin. ft. ¾" c.r. channels		.....	.....	.052	44.20
4 lbs. 16 ga. wire		.....	.....	.30	1.20
105 sq. yds. diamond mesh		.....	.....	.60	63.00
8 lbs. 18 ga. wire		.....	.....	.32	2.56
Lather*	25	.....	.....	6.50	162.50
Cost per 100 sq. yds.	25		$.....		$300.24
Cost per sq. yd.			.....		3.00

*See above for erection under concrete.

Cost of 100 Lin. Ft. Beam or Girder Fireproofing Using 3.4 Lb. Self-Furring Diamond Mesh Metal Lath Tied to Adjacent Ceiling Lath and Wrapped Downwards Around 12" WF Beam

	Hours	Rate	Total	Rate	Total
33 sq. yds. 3.4 lb. self-furring diamond mesh		$.....	$.....	$0.75	$24.75
2.5 lbs. 18 ga. wire		.....	.....	.32	.80
Lather	12	.....	.....	6.50	78.00
Cost per 100 lin. ft.	12		$.....		$103.55
Cost per lin. ft.			.....		1.04

Cost of 100 Sq. Yds. of Hollow Steel Stud Partitions; Lathed Both Sides, Studs 12″ on Centers, Using 2.5 Lb. Diamond Mesh Metal Lath

	Hours	Rate	Total	Rate	Total
200 lin. ft. snap-in runner track		$.....	$.....	$ 0.118	$ 23.60
Nails or expansion drives-allowance				15.00	15.00
101—9′-0″ steel studs (909 lin. ft.)*				0.118	107.26
210 sq. yds. diamond mesh				.50	105.00
17 lbs. 18 ga. wire				.32	5.44
Lather	27			6.50	175.50
Cost per 100 sq. yds.	27		$.....		$431.80
Cost per sq. yd.					4.32

*Add necessary extras for framing around openings, returns, etc.

Cost of 100 Sq. Yds. of Sound Insulation Partition Using Prefabricated Steel Studs 24″ on Centers, Resilient Clips and Pencil Rods, Lathed Both Sides With 3.4 Lb. ⅜″ Rib Metal Lath

	Hours	Rate	Total	Rate	Total
200 lin. ft. plain runner track		$.....	$.....	$ 0.118	$ 23.60
Nails or expansion drives-allowance				15.00	15.00
51—9′-0″ steel studs (459 lin. ft.)*				.118	54.16
204 shoes				.031	6.51
210 sq. yds. ⅜″ rib metal lath				.75	157.50
11 lbs. 18 ga. wire				.32	3.52
Lather	27			6.50	175.50
Add for sound treatment:					
100 lin. ft. cork, 3½″ wide x 1″ thick				.25	25.00
1020 resilient clips				.05	51.00
918 lin. ft. ¼″ rod				.025	22.95
Lather	5			6.50	32.50
Cost per 100 sq. yds.	32		$.....		$567.24
Cost per sq. yd.					5.67

*Add necessary extras for framing around openings, etc.

Cost of 100 Sq. Yds. Metal Lath Solid Partitions, Lathed One Side Only, Using Channels 16″ on Centers, Metal Floor and Ceiling Runners and 2.5 Lb. Diamond Mesh Metal Lath

	Hours	Rate	Total	Rate	Total
690 lin. ft. ¾″ cold rolled channel*		$.....	$.....	$ 0.052	$ 35.88
200 lin. ft. Z-type runner, slotted				.112	22.40
Nails or screws—allowance				15.00	15.00
105 sq. yds. diamond mesh				.50	52.50
8 lbs. 18 ga. wire				.32	2.56
Lather	37			6.50	240.50
Cost per 100 sq. yds.	37		$.....		$368.84
Cost per sq. yd.					3.69

Cost of 100 Sq. Yds. of Hollow Partitions (Concealment) Using Double Rows of ¾″ Channel Studs at 16″ on Centers and 3.4 Lb. Diamond Mesh Metal Lath

	Hours	Rate	Total	Rate	Total
152 pcs. ¾″ studs x 9′-2″ 1390 lin. ft.: (tops of studs tied to ceiling furring channels)*		$.....	$.....	$.....	$.....
208 lin. ft. ¾″ stiffener					
152 pcs. ¾″ spacer 512 lin. ft.: (based on 2′ between rows of studs					
Subtotal: 2110 lin. ft. ¾″ channel				.052	109.72
200 lin. ft. snap-on metal base				.35	70.00
152 single base clips (furring clip)				.04	6.08
Nails or expansion drive-allowance				10.00	10.00
210 sq. yds. diamond mesh				.60	126.00
17 lbs. 18 ga. wire				.32	5.44
Lather	32			6.50	208.00
Cost per 100 sq. yds.	32		$.....		$535.24
Cost per sq. yd.					5.35

*Add necessary extras for framing around openings, returns, etc.

Cost of 100 Sq. Yds. of Vertical Furring Using 2.75 Lb. Flat Rib Metal Lath and ¾" Channels 16" on Centers

	Hours	Rate	Total	Rate	Total
76 pcs. ¾" studs x 9'-0" 684 lin. ft.*		$.....	$.....	$.....	$.....
104 lin. ft: ¾" stiffener		.....	.....	.....	.....
51 pcs. ¾" braces x 2'-0" 102 lin. ft.		.....	.....	.....	.....
Subtotal: 890 lin. ft. ¾" channel		.....	.....	.052	46.28
200 lin. ft. double-pronged ceiling-floor runner		.....	.....	.118	23.60
Nails or expansion drives-allowance		.....	.....	15.00	15.00
105 sq. yds. flat rib metal lath		.....	.....	.75	78.75
8 lbs. 18 ga. wire		.....	.....	.32	2.56
Lather*	22	.....	.....	6.50	143.00
Cost per 100 sq. yds.	22		$.....		$309.19
Cost per sq. yd.			.....		3.09

*Add necessary extras for framing around openings, for soffits, returns, etc.

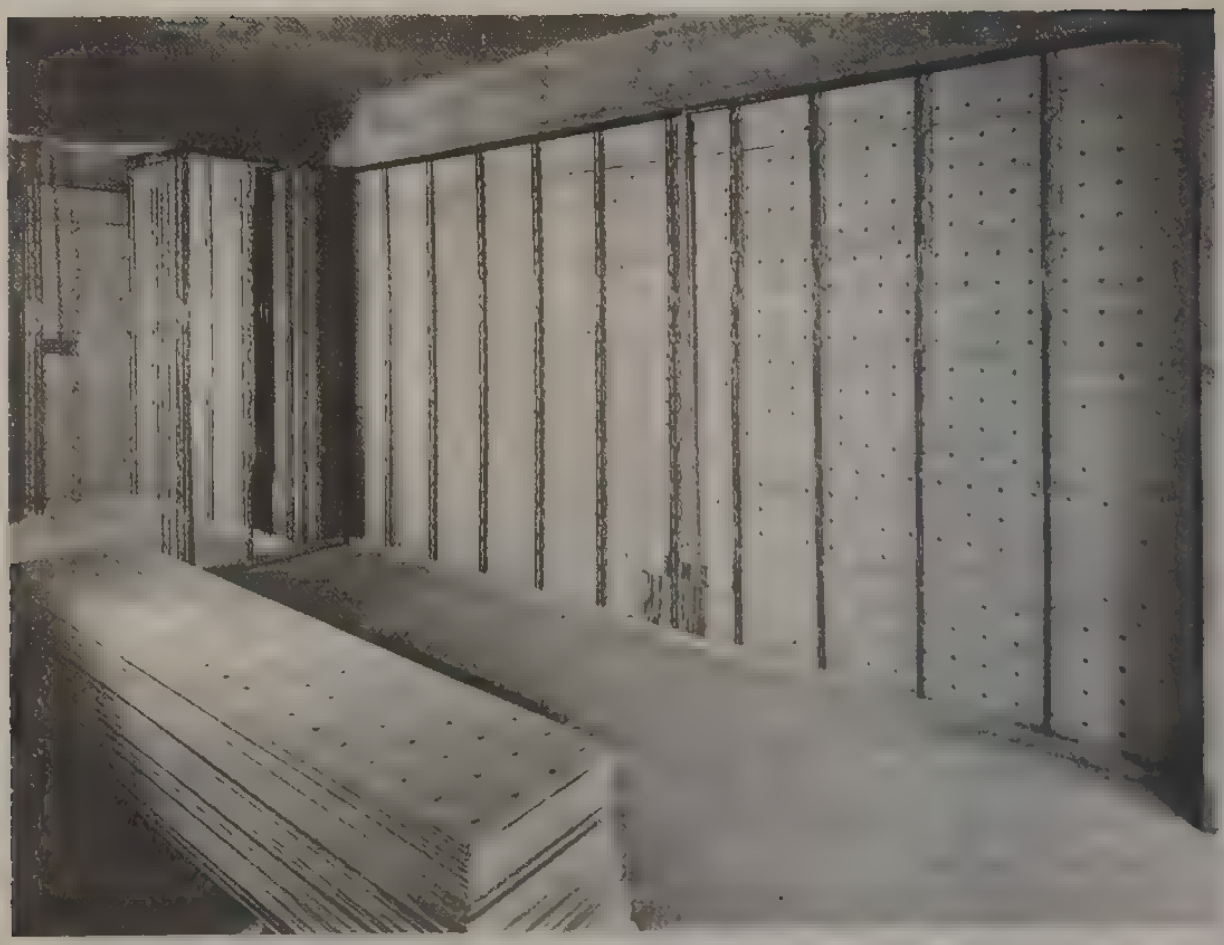
Cost of 100 Lin. Ft. of Metal Corner Bead Attached to Lath Bases

	Hours	Rate	Total	Rate	Total
100 lin. ft. corner bead		$.....	$.....	$0.10	$10.00
Staples or tie wire		.....	.....		.50
Lather	2.5	.....	.....	6.50	16.25
Cost per 100 lin. ft.	2.5		$.....		$26.75
Cost per lin. ft.			.....		.27

In estimating for other beads, molding or screeds, substitute proper material price, and for other bases consult discussion of labor on beads and molding for necessary additions to hours required (p. 1144). Also, if beads or molding are to serve as plaster grounds and all plumbing or straightening work is assigned to the installation of the accessory, add ½ hrs. per 100 lin. ft.

Cost of 100 Lin. Ft. Cornerite or Metal Lath Strips in Wall Angles and at Intersections of Walls and Furring

	Hours	Rate	Total	Rate	Total
100 lin. ft. cornerite		$.....	$.....	$0.04	$ 4.00
Staples or tie wire		.....	.....	.....	.50
Lather	1.5	.....	.....	6.50	9.75
Cost per 100 lin. ft.	1.5		$.....		$14.25
Cost per lin. ft.			.....		.14



Hollow Steel Stud Non-Bearing Partition

ESTIMATING PLASTER QUANTITIES

The following pages contain covering capacities and quantities of the different kinds of plastering materials required and are based on manufacturer's* specifications.

Gypsum plasters are sold by the ton and are usually packed in 100 lb. sacks. When sand is mixed with plaster in the proportion of 1 to 1, 1 to 2, or 1 to 3, it means 100, 200, or 300 lbs. of sand respectively are to be added to each 100 lb. sack of plaster.

Certain fire-resistant ratings may require an increase in the ratio of plaster to aggregate (such as 1:1; 1:2 in lieu of 1:2, 1:3) or an increase in the thickness of the plaster over normal grounds, or both, and the estimator must take this into consideration in the use of the following data.

Covering Capacity.—The covering capacity of plaster necessarily depends upon conditions under which the plaster is applied—upon the mechanic, thickness of grounds, kind and trueness of the surface to be plastered, type of lath, quality of sand, etc.

* U.S. Gypsum Co.

The covering capacity given in the following paragraphs for each type of material and for the various surfaces is based on average conditions, and may be accepted as a safe basis for calculating the quantity of each class of material required when applied according to manufacturer's* specifications.

Thickness of grounds will have considerable bearing on the covering capacity of plaster and the quantities given are based on the following: $\frac{3}{4}$" grounds for metal lath, or about $\frac{5}{8}$" of plaster over the face of the lath; $\frac{7}{8}$" grounds for $\frac{3}{8}$" gypsum lath or $\frac{1}{2}$" of plaster; 1" for $\frac{1}{2}$" insulating board lath or $\frac{1}{2}$" of plaster and $\frac{5}{8}$" for unit masonry.

Number of 100 Lb. Sacks of Gypsum Cement Plaster Required Per 100 Sq. Yds.

Kind of Plastering Surface		
Metal Lath	Gypsum Lath	Unit Masonry
18 to 20 (Sanded 1:2;1:3)	9 to 11 (Sanded 1:2;1:3)	10 to 12 (Sanded 1:3)
For each ⅛" in Thickness, Proportions 1:3; Add or Deduct Sacks		
2.5	2.5	2.5

For insulation board lath, use same plaster quantities as given for gypsum lath.

Standard specifications specify that the first (scratch) coat on all types of lath shall be mixed in the proportions of 1 part gypsum neat plaster to not more than 2 parts of sand by weight (or 100 lbs. of gypsum neat plaster to 2 cu. ft. of perlite or vermiculite aggregate).

First coat on masonry surfaces (except monolithic concrete) and second (brown) coat on all lath bases shall be mixed in the proportions of one (1) part gypsum neat plaster to not more than three (3) parts of sand by weight (or 100 lbs. of gypsum neat plaster to 2 cu. ft. of perlite or vermiculite aggregate).

The sacks of gypsum cement plaster shown in the table above per 100 sq. yds. for various bases are based on these proportions when used with sand aggregate.

Perlite and Vermiculite Plaster

Vermiculite is a mineral that expands when heated at about 2000° F. Each ore particle expands to about 12 times its original size. It will not rot, decay, burn or be attacked by vermin or termites.

Perlite is a siliceous volcanic rock mined in western United

*United States Gypsum Company.

States. When crushed and quickly heated to above 1500° F., it expands to form lightweight, non-combustible, inert glass-like particles of cellular structure. This material, white in color is about $\frac{1}{10}$ the weight of sand.

Perlite or vermiculite plaster aggregate is a lightweight material. Compared with 100 lbs. per cu. ft. for sand aggregate, perlite ranges from 7½ to 15 pounds per cu. ft., and vermiculite 6 to 10 pounds per cu. ft. Plaster using this aggregate will weigh approximately 30 to 45 lbs. per cu. ft. (depending upon proportions used), against 100 lbs. per cu. ft. where sand aggregate is used.

When perlite or vermiculite is expanded each granule has countless numbers of small dead air spaces which, in addition to making the material very light, gives it a high insulating value. It has approximately three and one half times as much insulating value as ordinary plaster.

It is this insulating quality that provides good fire resistance when combined with gypsum plaster. These aggregates are frequently called for when specific fire ratings are required for the protection of steel framing. As such fire ratings usually require greater plaster thicknesses than normal grounds provide, the estimator is cautioned to determine the proper quantities required per 100 sq. yds.

Perlite or vermiculite plaster aggregate is usually packed in multi-wall paper bags containing 3 or 4 cu. ft. Since there may be some compression or packing in shipping or storage, to insure correct proportioning do not use the original package but a cubic foot measuring box.

Machine-applied vermiculite portland cement plaster is used for panel or spandrel walls and exterior columns. The material has fire ratings of five and four hours, respectively. The contractor can apply it to exterior columns simultaneously with the wall, since the paper-backed wire fabric used in wall construction is also wrapped around the columns. The protection is also used for interior columns where more than ordinary wear and tear is expected due to the type of occupancy.

The following table gives the approximate quantities of gypsum plaster and perlite or vermiculite for 100 sq. yds. of various mixtures.

Recommended Proportions and Quantities

In the following table giving recommended proportions for gypsum plaster and perlite or vermiculite, the proportions 1 - 2, means 100 lbs. of gypsum plaster to 2 cu. ft. of perlite or vermiculite; 1 - 3 means 100 lbs. of gypsum plaster to 3 cu. ft. of perlite or vermiculite.

Type of Construction	Grounds (See Note)	Actual Plaster Thickness	Coat	Recommended Volume Proportions	Required per 100 Sq. Yds.	
					Bags Plaster	Cu. Ft. Aggregate
Metal Lath	¾"	¼"	Scratch	1—2	10	20
		7/16"	Brown	1—2	12½	45
Gypsum Lath	⅞"	3/16"	Scratch	1—2	5	10
		¼"	Brown	1—2	10	20
2" Solid Partition	2"	⅜"	Scratch (One side only)	1—2	15	30
		⅜"	Brown (One side only)	1—2	15	30
		1⅛"	Brown 2nd Side	1—2	45	90
Unit Masonry	⅝"	3/16"	Scratch	1—3	4	12
		⅜"	Brown	1—3	8	24

Note: Grounds attached to studs, joists or channels—not the lath. 1/16" allowed for finish coat thickness.

Number of 100 Lb. Sacks of Wood Fiber Plaster Required Per 100 Sq. Yds.

Kind of Plastering Surface		
Metal Lath	Gypsum Lath	Unit Masonry
32 to 34 Unsanded	17 to 18 Unsanded	12 to 14 Equal parts of sand by weight to be added
For each ⅛" in Thickness, Add or Deduct Sacks		
5	4½	3

For insulation board lath, use same plaster quantities as given for gypsum lath.

For two and three-coat work on all types of lath, gypsum wood fiber plaster may be used without the addition of aggregate.

For two and three-coat work on masonry surfaces and as scratch coat on lath (except monolithic concrete), gypsum wood fiber plaster shall be mixed in the proportions of 1 part of plaster to 1 part of sand, or perlite by weight.

Gypsum Ready-Mix Plasters Made with Lightweight Aggregate

Gypsum ready-mix plasters are generally made with perlite and the regular formula for lath bases is packed in 80-lb. sacks and the masonry formula for application over all masonry bases is packed in 67-lb. sacks.

The following table gives the number of sacks required per 100 sq. yds. applied over various surfaces:

Kind of Plastering Surface		
Metal Lath	Gypsum Lath	Unit Masonry
32 to 34*	17 to 19*	24 to 26**
For Each ⅜" in Thickness, Add or Deduct Sacks		
5	5	5

Quantity of Putty Obtained from Various Plastering Materials

The quantity of lime putty obtainable from one ton of lime will vary with the kind of lime used, whether pebble quicklime, pulverized quicklime or hydrated lime, also upon the quality of the lime, as lime produced in different parts of the country will produce varying amounts of lime putty.

Under average conditions the following quantities should be obtained.

Plastering Material	Cu. Ft. of Putty per Ton of Material	Lbs. Req'd for One Cu. Ft. Putty
Pebble quicklime	80	25
Pulverized quicklime	80	25
Hydrated lime	46	43½
Gypsum plaster	37	54
Keene's cement	30	66⅔
Portland cement	18½	109

BASE COAT

Covering Capacity of Lime Plaster.—There has been some confusion in the past regarding the covering capacity of lime plaster due to the lack of definite specifications covering the method of mixing and proportioning the materials.

Lime plaster is usually proportioned by volume, using 1 volume of stiff, well aged lime putty to 2 volumes of dry sand, plus necessary hair or fiber for scratch coat.

For the brown coat, use 1 volume of lime putty to 3 volumes of dry sand, plus hair or fiber as needed.

One cu. ft. of sand is considered 100 lbs. or 2,700 lbs. per cu. yd.

*80-lb. sacks. **67-lb. sacks.

Covering Capacity of One Cu. Yd. of Lime Plaster

Based on same thickness of grounds as given on previous pages.

	Plastering Surface Metal Lath	Unit Masonry ⅝-in. Grounds
Scratch Coat	50-60 sq. yds.	.....
Brown Coat	70-80 sq. yds.	60-75 sq. yds.

Bondcrete For Interior Concrete Surfaces.—Used as a bond coat on rough concrete surfaces only. If the concrete surfaces are smooth, they must be roughened by bush-hammering or hacking or a dash coat of portland cement grout, composed of one part portland cement and one and one-half parts of fine sand mixed to a mushy consistency, shall be applied. Use a stiff fiber brush forcibly dashing the mix onto the surface and damp cure for two days and then allow to dry.

Bondcrete adheres to dry concrete surfaces because of its cementitious qualities and because it maintains a practically unchanging volume during the process of setting and hardening.

On properly prepared rough concrete ceilings, apply a coat ot bond plaster scratched in thoroughly, double backed, and filled out to a true, even surface and left rough, ready to receive the finish coat. Total thickness of the plaster not to exceed ⅜".

On properly prepared rough concrete columns or walls, scratch in a minimum ¼" coat of bond plaster and then follow with a brown coat of gypsum plaster (one part gypsum neat plaster to not more than three parts sand, by weight) troweled into the scratch coat before it sets. Brown coat shall be brought out to ground, straightened to a true surface and left rough ready to receive the finish coat. Total thickness of plaster not to exceed ⅝".

It usually requires 1,700 to 2,200 lbs. of Bondcrete per 100 sq. yds. depending upon the regularity of the concrete surface and thickness applied.

Plaster-Weld*.—Plaster-Weld permanently bonds new gypsum plaster (finish or base coat), or acoustical plaster to such surfaces as concrete, plain plastered walls or ceilings, oil painted plaster walls, stippled or textured walls, brick, wood, concrete block, gypsum block, gypsum lath, marble, and many other surfaces. Cannot be used over calcimine or other water soluble coatings.

No chipping or roughening of surfaces is required. The surface must be structurally sound and free from dust, dirt, grease, oil or wax.

May be applied by brush, roller or spray equipment. After allowing Plaster-Weld to become dry to the touch (one hour on

*Larsen Products Corp., Bethesda, Md.

porous surfaces and two hours on non-porous surfaces), plaster can be applied either immediately or later. Too much time lag in excess of a week or ten days may require recoating.

Plaster-Weld covers up to 500 sq. ft. per gal. when sprayed on, which gives the most satisfactory results. When applied by brush or roller, coverage is reduced.

When sprayed on the cost per 100 sq. yds. should average as follows:

	Hours	Rate	Total	Rate	Total
1.8 gals. Plaster-Weld....		$.....	$.....	$10.50	$18.90
Labor	2.25	.....	.....	5.00	11.25
Spray-gun equipment	2.25	.....	.....	1.00	2.25
Cost 100 sq. yds.....	2.25		$.....		$32.40
Cost per sq. yd.....			.....		.324
Cost per sq. ft.....			.....		.036

Plaster-Weld costs approximately $10.50 per gal. in 1-gal. cans; $10.25 per gal. in 55 gal. drums.

Finishing Lime.—Finishing lime is essential to two common types of job mixed finish coats—the white putty coat trowel finish and the sand float finish.

For the trowel finish coat, the proportion is generally 1 part of gypsum gauging plaster to 2 parts of hydrated lime on a dry weight basis, or 100 lbs. of gypsum gauging plaster to 4½ cu. ft. of lime putty. One ton of gypsum gauging plaster and 2 tons of hydrated finishing lime, or 90 cu. ft. of lime putty will finish approximately 1,200 sq. yds.

While a sand float finish may be mixed with 1 part of lime putty and 2½ to 3 parts of sand, it is generally necessary to add Keene's cement or gypsum gauging plaster to give the finish early hardness and strength. A standard mix for a Keene's cement-lime putty sand float finish is 2 parts of lime putty to 1½ parts of Keene's cement and 4½ parts of sand by volume. This is equivalent to 1 ton of hydrated lime, or 45 cu. ft. of putty, to 1¼ tons of Keene's cement and 4¾ tons of sand and this quantity will cover approximately 1,600 sq. yds.

If type "S" (fully) hydrated limes are used, they must be added to the mix in dry form, as they form immediate plasticity on wetting. If quicklimes are used, they must be slaked and properly aged and added to the mix in the volume indicated above for putty.

Prepared Gypsum Trowel Finishes.—There are a number of prepared gypsum trowel finishes on the market which require only the addition of water to make them ready for use. A

few of these are Universal White Trowel Finish, Red Top* Trowel, and Red Top* Imperial.

Under average conditions, if mixed and applied in accordance with standard specifications, one ton will cover 350 to 400 sq. yds. of surface or it requires 500 to 575 lbs. per 100 sq. yds.

Prepared Gypsum Sand Float Finishes.—There are a number of gypsum sand float finishes, such as Red Top* Sand Float Finish.

These finishes are ready for use when water is added and under average conditions one ton is sufficient for 250 to 275 sq. yds. or it requires 725 to 800 lbs., per 100 sq. yds.

Estimating Labor Costs of Plastering

Before it is possible to prepare an accurate estimate on the cost of any plastering job, the quality of work must be considered, as labor costs may vary up to 25 or 30 percent.

The costs given on the following pages cover two grades of workmanship, which are fully described at the beginning of this chapter.

Applying Scratch Coat of Plaster.—A plasterer should apply 140 to 165 sq. yds. of scratch coat per 8-hr. day, where ordinary grade of workmanship is required, and 135 to 155 sq. yds. per 8-hr. day where first grade workmanship is required.

Applying Brown Coat.—Where an ordinary grade of workmanship is required, a plasterer should apply 90 to 110 sq. yds. of brown coat per 8-hr. day.

Where first grade workmanship is required, a plasterer should brown out 70 to 85 sq. yds. per 8-hr. day.

Applying "Scratch—Double-Back" Basecoat.—Over masonry bases and in many markets over gypsum lath base it is common practice to apply a single plaster mix in a "scratch-in" and "double-back" operation to fill out to grounds.

For ordinary work, a plasterer should apply 90 to 110 sq. yds. per 8-hr. day, and for first grade workmanship, a plasterer should apply 70 to 85 sq. yds. per 8-hr. day in this manner.

Applying White Finish or "Putty" Coat. –On an ordinary job of white coating, a plasterer should apply 90 to 110 sq. yds. per 8-hr. day.

Where first grade workmanship is specified, a plasterer will apply 60 to 80 sq. yds. per 8-hr. day.

General Notes Applying to Finish Plaster Coats

All of the tables on the following pages give costs on a finish white coat. If wanted with sand float finish, deduct quantities given in tables for Finish White Coat and add cost of Sand Float

*United States Gypsum Company.

Finish as given on the following pages under "Sand Float Finish."

Applying Sand Float Finish.—A plasterer should apply 100 to 120 sq. yds. of simple sand float finish per 8-hr. day, where an ordinary grade of workmanship is required or 70 to 90 sq. yds. where first grade workmanship is required.

Labor Applying 100 Sq. Yds. of Plaster to Various Plaster Bases

Ordinary Workmanship

Description of Work	Sq. Yds. per 8-Hour Day	Plasterer Hours	Labor Hours
Gypsum Mortar on Gypsum lath -½" Plaster—2-Coat Work 1:2½ Brown Coat	90-110	8	5
Gypsum Mortar on Unit Masonry —⅝" Plaster—2-Coat Work—1:3 Brown Coat	80-100	9	6
Lime Mortar on Unit Masonry —⅝" Plaster—2-Coat Work Brown Coat 1:3	90-100	8.5	5.5
Lime Mortar on Metal Lath—¾" Grounds—⅝" Plaster—3-Coat Work			
Scratch Coat 1:2	150-160	5	5
Brown Coat 1:3	90-110	8	5
Lime Mortar on Unit Masonry —⅝" Plaster—3-Coat Work			
Scratch Coat 1:2	150-160	5	5
Brown Coat 1:3	90-110	8	5
Gypsum Mortar on Unit Masonry Tile—⅝" Plaster—3-Coat Work			
Scratch Coat 1:3	150-160	5	5
Brown Coat 1:3	90-110	8	5
Gypsum Mortar on Gypsum Lath—½" Plaster—3-Coat Work			
Scratch Coat 1:2	150-160	5	5
Brown Coat 1:3	90-110	8	5
Gypsum Mortar on Metal Lath ¾" Grounds—⅝" Plaster—3-Coat Work			
Scratch Coat 1:2	150-160	5	5
Brown Coat 1:3	85-100	9	6
Two (2") Inch Solid Plaster Partitions—Metal Lath One Side—Back Up — Finished 2 Sides — Gypsum Mortar ¾" Grounds—2" Plaster			
Scratch Coat 1:2	150-160	5	5
Back Up Coat 1:2	150-160	5	5
2 Brown Coats 1:2	40- 50	18	12

Labor Applying 100 Sq. Yds. of Plaster to Various Plaster Bases

Ordinary Workmanship

Description of Work	Sq. Yds. per 8-Hour Day	Plasterer Hours	Labor Hours
Hollow Stud Partitions—Lathed 2 Sides—Plastered to ¾" Grounds....			
Scratch Coat 1:2—2 Sides	75- 80	10	10
Brown Coat—2 Sides	40- 50	18	12
Finish White Coat—All Classes of Undercoat	90-110	8	4
Sand Finish Coat — All Classes of Undercoat	100-120	7.25	5
First Grade Workmanship—Where First Grade Workmanship is Required as described on the previous pages, add to Hours Given above			
Brown Coat	.....	2.25	1
Finish White Coat	.....	3.50	1
Sand Finish	.....	2.75	1

Applying Finish Coat of Cement Wainscoting.—Where cement plaster finishes are used in kitchens, bathrooms, laundries, corridors, etc., using Keene's cement, or similar finishes applied over a brown coat of gypsum cement plaster or portland cement, a plasterer should apply 50 to 60 sq. yds. per 8-hr. day.

If the wainscoting is blocked off into squares, 3"x6", 4"x4" or 6"x6" to represent tile, a plasterer should block off 45 to 55 sq. yds. per 8-hr. day.

To apply the finish coat of plaster and block same off into squares to represent tile, a plasterer should complete 25 to 30 sq. yds. per 8-hr. day.

Where first grade workmanship is required, a plasterer should apply 35 to 45 sq. yds. of cement wainscoting per 8-hr. day, and block off 40 to 45 sq. yds. or he will apply cement wainscoting and block off 18 to 22 sq. yds. per 8-hr. day.

ITEMIZED PLASTERING COSTS

The itemized costs given on the following pages are intended to furnish the estimator and contractor detailed information regarding material quantities and labor costs on all kinds of plastering.

All plaster quantities are based on thickness of grounds as given and if the work is "skimped" and the plaster does not fill out the grounds or is applied thinner than specified, then the quantities in the tables will not prove correct. Also, if

sand is not added in accordance with manufacturer's specifications, the quantities may be more or less than given in the tables.

Labor hours include time required for building and removing ordinary scaffolding, but will not cover scaffolding for high work in churches, auditoriums, etc. For this type of scaffolding, refer to Tubular Steel Scaffolding given in Chapter 4.

Lathing and Plastering Contractors' Overhead Expense and Profit

The itemized costs given on the following pages do not include lathing or plastering contractors' overhead expense and profit, which will have to be added.

This includes tools and equipment, truck, workmen's compensation and public liability insurance, old age benefit and unemployment compensation taxes; welfare fund, paid holidays, etc.

This may add 25 to 40 percent to the itemized costs given on the following pages, depending upon size of the job and the contractor performing the work.

2-COAT PLASTERING

Cost of 100 Sq. Yds. 2-Coat Gypsum Cement Plaster, White Finish on Gypsum Lath

Add for gypsum lath.

Ordinary Workmanship—⅞" Grounds—½" Plaster

Brown Coat—1:2.5	Hours	Rate	Total	Rate	Total
1,000 lbs. gypsum plaster.		.....	.....	$1.60*	$ 16.00
25 cu. ft. sand		.....	.....	.17	4.25
Plasterer	8	.....	.....	6.50	52.00
Labor	5	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40*	8.16
170 lbs. gauging plaster..		.....	.....	2.00*	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	25		$.....		$180.81
Cost per sq. yd.					1.81

*100 lb. bag.

Cost of 100 Sq. Yds. 2-Coat Gypsum Cement Plaster, White Finish on Unit Masonry

Ordinary Workmanship—⅝" Grounds

Brown Coat—1:3	Hours	Rate	Total	Rate	Total
1,100 lbs. gypsum plaster.		$.....	$.....	$1.60	$ 17.60
33 cu. ft. sand		.....	.....	.17	5.61
Plasterer	9	.....	.....	6.50	58.50
Labor	6	.....	.....	5.00	30.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	27		$.....		$195.27
Cost per sq. yd.			.....		1.95

Cost of 100 Sq. Yds. 2-Coat Bondcrete Plaster, White Finish on Concrete Ceilings

Bondcrete plaster can only be applied to rough concrete surfaces. If the concrete surfaces are smooth, they must be roughened by bush-hammering or hacking or a dash coat of portland cement grout, composed of one part portland cement and one and one-half parts fine sand, mixed to a mushy consistency. Use a stiff fiber brush forcibly dashing the mix onto the surface and damp cure for two days and then allow to dry.

For costs on this work refer to chapter on "Waterproofing."

Ordinary Workmanship—Plaster ⅝" Thick

Brown Coat	Hours	Rate	Total	Rate	Total
2,000 lbs. Bondcrete		$.....	$.....	$1.80	$ 36.00
Plasterer	8	.....	.....	6.50	52.00
Labor	5	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	25		$.....		$196.56
Cost per sq. yd.			.....		1.97

Cost of 100 Sq. Yds. 2-Coat Wood Fiber Plaster, White Finish on Gypsum Lath

Add for gypsum lath.

Ordinary Workmanship—⅞" Grounds—½" Plaster

Brown Coat	Hours	Rate	Total	Rate	Total
1,700 lbs. wood fiber		$.....	$.....	$1.60	$ 27.20
Plasterer	9	.....	.....	6.50	58.50
Labor	5	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.	26		$.....		$194.26
Cost per sq. yd.			.....		1.94

3-COAT PLASTERING

Cost of 100 Sq. Yds. 3-Coat Gypsum Cement Plaster, White Finish on Gypsum Lath

Add for gypsum lath.

Ordinary Workmanship—⅞" Grounds—½" Plaster

Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
400 lbs. gypsum plaster		.....	.....	$1.60	$ 6.40
8 cu. ft. sand		.....	.....	.17	1.36
Plasterer	5	.....	.....	6.50	32.50
Labor	5	.....	.....	5.00	25.00
Brown Coat—1:3					
700 lbs. gypsum plaster		.....	.....	1.60	11.20
21 cu. ft. sand		.....	.....	.17	3.57
Plasterer	8	.....	.....	6.50	52.00
Labor	5	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.	35		$.....		$240.59
Cost per sq. yd.			.....		2.41

If first grade workmanship is required, add 5.75 hrs. plasterer time and 2 hrs. labor time per 100 sq. yds.

Cost of 100 Sq. Yds. 3-Coat Gypsum Cement Plaster, White Finish on Unit Masonry

Ordinary Workmanship—⅝" Grounds

Scratch Coat—1:3	Hours	Rate	Total	Rate	Total
500 lbs. gypsum plaster..		$.....	$.....	$1.60	$ 8.00
15 cu. ft. sand		.....	.....	.17	2.55
Plasterer	5	.....	.....	6.50	32.50
Labor	5	.....	.....	5.00	25.00
Brown Coat—1:3					
700 lbs. gypsum plaster..		.....	.....	1.60	11.20
21 cu. ft. sand		.....	.....	.17	3.57
Plasterer	8	.....	.....	6.50	52.00
Labor	5	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	35		$.....		$243.38
Cost per sq. yd.					2.43

If first grade workmanship is required, add 5.75 hrs. plasterer time and 2 hrs. labor time per 100 sq. yds.

Applying Plaster Scratch Coat to Metal Lath Walls and Ceilings

Cost of 100 Sq. Yds. 3-Coat Gypsum Cement Plaster, White Finish on Metal Lath Walls and Ceilings

Add for metal lath and furring.

Ordinary Workmanship—¾" Grounds—⅝" Plaster					
Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
800 lbs. gypsum plaster...		$.....	$.....	$1.60	$ 12.80
16 cu. ft. sand.....		.....	.....	.17	2.72
Plasterer	5	.....	.....	6.50	32.50
Labor	5	.....	.....	5.00	25.00
Brown Coat—1:3					
1,200 lbs. gypsum plaster..		.....	.....	1.60	19.20
36 cu. ft. sand.....		.....	.....	.17	6.12
Plasterer	9	.....	.....	6.50	58.50
Labor	6	.....	.....	5.00	30.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster.		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	37		$.....		$270.40
Cost per sq. yd.....					2.70

If first grade workmanship is required, add 5.75 hrs. plasterer time and 2 hrs. labor time per 100 sq. yds.

Cost of 100 Sq. Yds. 2" Solid Plaster Partitions on Metal Lath

Measurement taken on one side only. Add for metal lath and furring.

Ordinary Workmanship					
Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
2,000 lbs. gypsum plaster.		$.....	$.....	$1.60	$ 32.00
40 cu. ft. sand.....		.....	.....	.17	6.80
Plasterer	10	.....	.....	6.50	65.00
Labor	10	.....	.....	5.00	50.00
Brown Coat—1:3					
2,800 lbs. gypsum plaster..		.....	.....	1.60	44.80
84 cu. ft. sand.....		.....	.....	.17	14.28
Plasterer	18	.....	.....	6.50	117.00
Labor	12	.....	.....	5.00	60.00
Finish White Coat					
680 lbs. fin. hydrated lime		.....	.....	2.40	16.32
340 lbs. gauging plaster.		.....	.....	2.00	6.80
Plasterer	16	.....	.....	6.50	104.00
Labor	8	.....	.....	5.00	40.00
Cost 100 sq. yds.....	74		$.....		$557.00
Cost per sq. yd.....			.....		5.57

If first grade workmanship is required, add 11.5 hrs. plasterer time and 4 hrs. labor time per 100 sq. yds.

Cost of 100 Sq. Yds. 2″ Solid Gypsum Long Length Lath and Plaster Partition

Add for gypsum lath.

Ordinary Workmanship

Partition 2″ Thick; ½″ Gypsum Lath; ¾″ of Plaster Each Side of Lath

Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
800 lbs. gypsum plaster...		$.....	$.....	$1.60	$ 12.80
16 cu. ft. sand.....		.....	.....	.17	2.72
Plasterer	10	.....	.....	6.50	65.00
Labor	10	.....	.....	5.00	50.00
Brown Coat—1:3					
2,400 lbs. gypsum plaster..		.....	.....	1.60	38.40
72 cu. ft. sand.....		.....	.....	.17	12.24
Plasterer	16	.....	.....	6.50	104.00
Labor	10	.....	.....	5.00	50.00
Finish White Coat					
680 lbs. fin. hydrated lime		.....	.....	2.40	16.32
340 lbs. gauging plaster...		.....	.....	2.00	6.80
Plasterer	16	.....	.....	6.50	104.00
Labor	8	.....	.....	5.00	40.00
Cost 100 sq. yds.....	70		$.....		502.28
Cost per sq. yd.....					5.02

Cost of 100 Sq. Yds. 2″ Solid Studless Metal Lath and Plaster Partition

Add for metal lath and furring.

Ordinary Workmanship

Partition 2″ Thick; 3.4-lb. Metal Lath; Plaster 2″ Thick

Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
2,000 lbs. gypsum plaster.		$.....	$.....	$1.60	$ 32.00
40 cu. ft. sand		.....	.....	.17	6.80
Plasterer	10	.....	.....	6.50	65.00
Labor	10	.....	.....	5.00	50.00
Brown Coat—1:3					
2,800 lbs. gypsum plaster		.....	.....	1.60	44.80
84 cu. ft. sand		.....	.....	.17	14.28
Plasterer	18	.....	.....	6.50	117.00
Labor	12	.....	.....	5.00	60.00
Finish White Coat					
680 lbs. fin. hydrated lime		.....	.....	2.40	16.32
340 lbs. gauging plaster..		.....	.....	2.00	6.80
Plasterer	16	.....	.....	6.50	104.00
Labor	8	.....	.....	5.00	40.00
Cost 100 sq. yds.....	74		$.....		$557.00
Cost per sq. yd.....					5.57

Cost of 100 Sq. Yds. 3-Coat Bondcrete Plaster, White Finish on Concrete Walls and Columns

Add for preparing concrete surfaces, if required.

On properly prepared rough concrete columns or walls, scratch in a minimum ¼" coat of bond plaster and then follow with a brown coat of gypsum plaster (one part gypsum neat plaster to not more than three parts sand, by weight) troweled into the scratch coat before it sets. Brown coat shall be brought out to grounds, straightened to a true surface and left rough ready to receive the finish coat. Total thickness of plaster not to exceed ⅝".

Ordinary Workmanship—Plaster ⅝" Thick

Scratch Coat—¼"	Hours	Rate	Total	Rate	Total
1,500 lbs. Bondcrete		$.....	$.....	$1.80	$ 27.00
Plasterer	5	.....	.....	6.50	32.50
Labor	5	.....	.....	5.00	25.00
Brown Coat—1:3					
800 lbs. gypsum plaster		.....	.....	1.60	12.80
24 cu. ft. sand		.....	.....	.17	4.08
Plasterer	8	.....	.....	6.50	52.00
Labor	5	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.	35		$.....		$261.94
Cost per sq. yd.			.....		2.62

If first grade workmanship is required, add 5.75 hrs. plasterer time and 2 hrs. labor time per 100 sq. yds.

Cost of 100 Sq. Yds. 3-Coat Wood Fiber Plaster, White Finish on Metal Lath Walls and Ceilings

Add for metal lath and furring.

Ordinary Workmanship—¾" Grounds—⅝" Plaster

Scratch Coat	Hours	Rate	Total	Rate	Total
1,100 lbs. wood fiber		$.....	$.....	$1.60	$ 17.60
Plasterer	5.5	.....	.....	6.50	35.75
Labor	5.0	.....	.....	5.00	25.00
Brown Coat					
2,300 lbs. wood fiber		.....	.....	1.60	36.80
Plasterer	10.0	.....	.....	6.50	65.00
Labor	6.0	.....	.....	5.00	30.00
Carried Forward	26.5		$.....		$210.15

Cost of 100 Sq. Yds. 3-Coat Wood Fiber Plaster, White Finish on Metal Lath Walls and Ceilings—(Continued)

	Hours	Rate	Total	Rate	Total
Brought Forward	26.5	$.....	$.....	$....	$210.15
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster...		.....	.....	2.00	3.40
Plasterer	8.0	.....	.....	6.50	52.00
Labor	4.0	.....	.....	5.00	20.00
Cost 100 sq. yds.	38.5		$.....		$293.71
Cost per sq. yd.			.....		2.94

If first grade workmanship is required, add 5.75 hrs. plasterer time and 2 hrs. labor time per 100 sq. yds.

Plastering Radiant Panel Heat Ceilings.—Where radiant panel heating coils are embedded in ceiling plaster, base coat plastering costs will be higher than normal for both material and labor.

For this type of heating, $\frac{3}{8}$" I.D. ($\frac{1}{2}$" O.D.) copper tubing or electric cable is secured to ceiling framing after lath is installed, contacting underside of same. For proper operation of the heating system, all ceiling coils must be completely embedded in plaster, in perfect contact with plaster (no air pockets permitted) and have a plaster cover of $\frac{3}{8}$" or more. This means at least $\frac{7}{8}$" of plaster below the face of the lath for copper tubing and $\frac{1}{2}$"± for electric cable.

Scratch coat application is more difficult, due to the care which must be taken to obtain proper contact with tubing. Brown coat application will require more labor, due to the increased thickness of material required and the difficulty in making it stick to the ceiling. In some cases, a second scratch coat may be necessary to obtain the required thickness.

There should be no change in the method or cost of applying the various plaster finish coats.

Use sand aggregate only for radiant heat ceilings and walls. Lightweight aggregate is an insulator.

Cost of 100 Sq. Yds. 3-Coat Gypsum Plaster $\frac{7}{8}$" Thick, Applied to Gypsum Lath Ceilings with Radiant Heating Coils Embedded in the Plaster

Add for gypsum lath.

Ordinary Workmanship—$\frac{7}{8}$" Plaster

Scratch Coat 1:2	Hours	Rate	Total	Rate	Total
400 lbs. gypsum plaster...		$.....	$.....	$1.60	$ 6.40
8 cu. ft. sand.....		.....	.....	.17	1.36
Plasterer	6	.....	.....	6.50	39.00
Labor	6	.....	.....	5.00	30.00
Brown Coat 1:3					
1,400 lbs. gypsum plaster..		.....	.....	1.60	22.40
42 cu. ft. sand.....		.....	.....	.17	7.14
Plasterer	10	.....	.....	6.50	65.00
Labor	6	.....	.....	5.00	30.00
Finish White Coat					
340 lbs. fin. hydrated lime.		.....	.....	2.40	8.16
170 lbs. gauging plaster...		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	40		$.....		$284.86
Cost per sq. yd.....			.....		2.85

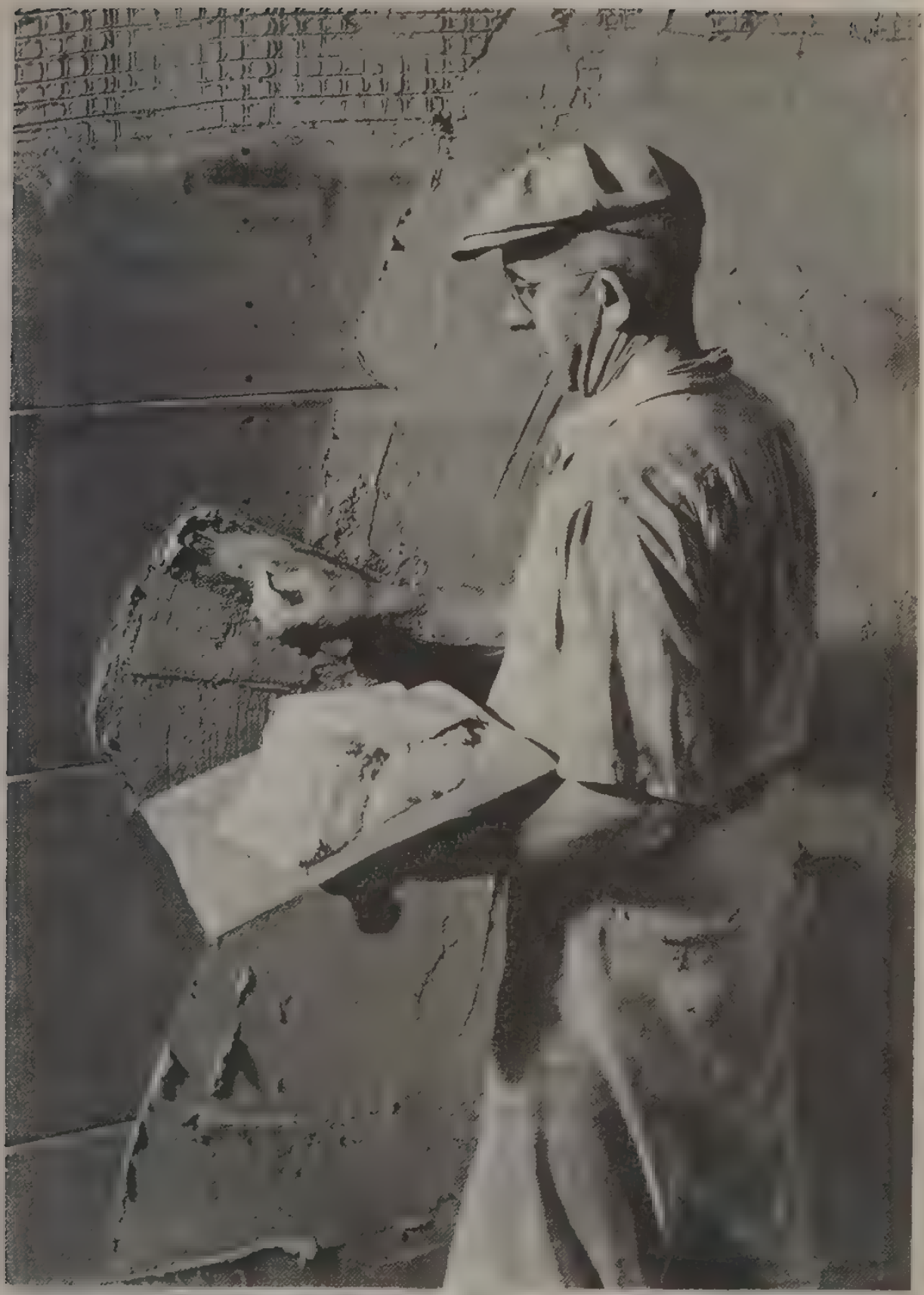
Cost of 100 Sq. Yds. of 3-Coat Gypsum Plaster $\frac{5}{8}$" Thick, Applied to Metal Lath Ceilings With Radiant Electric Heating Cables Embedded in the Plaster

Add for metal lath.

Ordinary Workmanship—$\frac{5}{8}$" Plaster

Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
800 lbs. gypsum plaster..		$.....	$.....	$1.60	$12.80
16 cu. ft. sand		.....	.....	.17	2.72
Plasterer	6	.....	.....	6.50	39.00
Labor	6	.....	.....	5.00	30.00
Brown Coat—1:3					
1,200 lbs. gypsum plaster.		.....	.....	1.60	19.20
36 cu. ft. sand		.....	.....	.17	6.12
Plasterer	9	.....	.....	6.50	58.50
Labor	6	.....	.....	5.00	30.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	39		$.....		$281.90
Cost per sq. yd.			.....		2.82

If it is necessary to apply the plaster in four coats instead of



Applying Plaster Scratch Coat to Gypsum Lath Wall.

three, add labor for a second scratch coat, as follows:

	Hours	Rate	Total	Rate	Total
Plasterer	6	$.....	$.....	$6.50	$39.00
Labor	6	.....	.....	5.00	30.00
Cost 100 sq. yds.	12		$.....		$69.00
Cost per sq. yd.			.....		.69

Labor Applying Perlite or Vermiculite Plaster

When using perlite or vermiculite plaster aggregate, a plasterer is applying material weighing 30 to 45 lbs. per cu. ft. against 100 lbs. per cu. ft. for gypsum-sand plaster, so that a plasterer can apply a greater yardage of light aggregate plaster if he is so inclined.

Cost of 100 Sq. Yds. 3-Coat Plaster Applied to Gypsum Lath, Using Perlite or Vermiculite Aggregate

Add for gypsum lath.

Ordinary Workmanship—⅞" Grounds—½" of Plaster

Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
500 lbs. gypsum plaster...		$.....	$.....	$1.60	$ 8.00
10 cu. ft. aggregate.....		.....	.....	.60	6.00
Plasterer	4.5	.....	.....	6.50	29.25
Labor	4.5	.....	.....	5.00	22.50
Brown Coat—1:2					
1,000 lbs. gypsum plaster..		.....	.....	1.60	16.00
20 cu. ft. aggregate.....		.....	.....	.60	12.00
Plasterer	7.5	.....	.....	6.50	48.75
Labor	5.0	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8.0	.....	.....	6.50	52.00
Labor	4.0	.....	.....	5.00	20.00
Cost 100 sq. yds.....	33.5		$.....		$251.06
Cost per sq. yd.....			.....		2.51

Cost of 100 Sq. Yds. 3-Coat Plaster Applied to Unit Masonry Walls, Using Perlite or Vermiculite Aggregate

Ordinary Workmanship ⅝" Grounds—⅝" of Plaster

Scratch Coat—1:3	Hours	Rate	Total	Rate	Total
400 lbs. gypsum plaster...		$.....	$.....	$1.60	$ 6.40
12 cu. ft. aggregate.....		.....	.....	.60	7.20
Plasterer	4.5	.....	.....	6.50	29.25
Labor	4.5	.....	.....	5.00	22.50
Carried Forward	9.0		$.....		$65.35

Cost of 100 Sq. Yds. 3-Coat Plaster Applied to Unit Masonry Walls, Using Perlite or Vermiculite Aggregate—(Continued)

	Hours	Rate	Total	Rate	Total
Brought Forward	9.0	$.....	$.....	$.....	$65.35
Brown Coat—1:3					
800 lbs. gypsum plaster...		.....	.....	1.60	12.80
24 cu. ft. aggregate.....		.....	.....	.60	14.40
Plasterer	7.5	.....	.....	6.50	48.75
Labor	5	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster...		.....	.....	2.00	3.40
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	33.5		$.....		$249.86
Cost per sq. yd.....					2.50

Cost of 100 Sq. Yds. 3-Coat Plaster Applied to Metal Lath, Using Perlite or Vermiculite Aggregate

Add for metal lath and furring.

Ordinary Workmanship—¾" Grounds—¾" Plaster

Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
1,000 lbs. gypsum plaster.		$.....	$.....	$1.60	$ 16.00
20 cu. ft. aggregate		.....	.....	.60	12.00
Plasterer	4.5	.....	.....	6.50	29.25
Labor	4.5	.....	.....	5.00	22.50
Brown Coat—1:2					
1,250 lbs. gypsum plaster.		.....	.....	1.60	20.00
40 cu. ft. aggregate		.....	.....	.60	24.00
Plasterer	8.0	.....	.....	6.50	52.00
Labor	6.0	.....	.....	5.00	30.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8.0	.....	.....	6.50	52.00
Labor	4.0	.....	.....	5.00	20.00
Cost per 100 sq. yds.....	35.0		$.....		$289.31
Cost per sq. yd.....			.....		2.89

Cost of 100 Sq. Yds. 2" Solid Plaster Partition Applied to Metal Lath, Using Perlite or Vermiculite Aggregate

(Measurement One Side Only)

Add for metal lath and furring.

Ordinary Workmanship—2" Partition—2" of Plaster

Scratch Coat—1:2	Hours	Rate	Total	Rate	Total
1,500 lbs. gypsum plaster.		$.....	$.....	$1.60	$ 24.00
30 cu. ft. aggregate.....		.....	.....	.60	18.00
Plasterer	5	.....	.....	6.50	32.50
Labor	5	.....	.....	5.00	25.00
Brown Coat—1:2					
6,000 lbs. gypsum plaster.		.....	.....	1.60	96.00
120 cu. ft. aggregate		.....	.....	.60	72.00
Plasterer	23	.....	.....	6.50	149.50
Labor	17.0	.....	.....	5.00	85.00
Finish White Coat					
680 lbs. fin. hydrated lime		.....	.....	2.40	16.32
340 lbs. gauging plaster..		.....	.....	2.00	6.80
Plasterer	16.0	.....	.....	6.50	104.00
Labor	8.0	.....	.....	5.00	40.00
Cost 100 sq. yds.....	74.0		$.....		$669.12
Cost per sq. yd.....					6.69

Cost of 100 Sq. Yds. 3-Coat Plaster (Scratch-Double-Back Basecoat) Applied to Gypsum Lath Using Pre-Mixed Perlite Plaster

Add for gypsum lath.

Ordinary Workmanship—⅞" Grounds—½" of Plaster

Scratch Coat	Hours	Rate	Total	Rate	Total
8 80 lb. sacks P. plaster..		$.....	$.....	$2.10	$ 16.80
Plasterer	4.5	.....	.....	6.50	29.25
Labor	4.5	.....	.....	5.00	22.50
Double-Back Brown Coat					
11 80-lb. sacks P. Plaster.		.....	.....	2.10	23.10
Plasterer	7.5	.....	.....	6.50	48.75
Labor	5.0	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8.0	.....	.....	6.50	52.00
Labor	4.0	.....	.....	5.00	20.00
Cost 100 sq. yds.....	33.5		$.....		$248.96
Cost per sq. yd.....					2.49

Cost of 100 Sq. Yds. 3-Coat Plaster (Scratch-Double-Back Basecoat) Applied to Unit Masonry Walls Using Pre-Mixed Perlite Plaster

Ordinary Workmanship—⅝" Grounds—⅝" of Plaster

Scratch Coat	Hours	Rate	Total	Rate	Total
10–80-lb. sacks P. Plaster.		$.....	$.....	$2.10	$ 21.00
Plasterer	4.5	.....	.....	6.50	29.25
Labor	4.5	.....	.....	5.00	22.50
Double-Back Brown Coat					
16–80-lb. sacks P. Plaster.		.....	.....	2.10	33.60
Plasterer	7.5	.....	.....	6.50	48.75
Labor	5.0	.....	.....	5.00	25.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8.0	.....	.....	6.50	52.00
Labor	4.0	.....	.....	5.00	20.00
Cost 100 sq. yds.....	33.5		$.....		$263.66
Cost per sq. yd.....			.....		2.64

Cost of 100 Sq. Yds. 3-Coat Plaster Applied to Metal Lath Using Pre-Mixed Perlite Plaster

Add for metal lath and furring.

Ordinary Workmanship -¾" Grounds—¾" Plaster

Scratch Coat	Hours	Rate	Total	Rate	Total
15–80-lb. sacks P. Plaster.		$.....	$.....	$2.10	$ 31.50
Plasterer	4.5	.....	.....	6.50	29.25
Labor	4.5	.....	.....	5.00	22.50
Brown Coat					
18–80-lb. sacks P. Plaster.		.....	.....	2.10	37.80
Plasterer	8.0	.....	.....	6.50	52.00
Labor	6.0	.....	.....	5.00	30.00
Finish White Coat					
340 lbs. fin. hydrated lime		.....	.....	2.40	8.16
170 lbs. gauging plaster..		.....	.....	2.00	3.40
Plasterer	8.0	.....	.....	6.50	52.00
Labor	4.0	.....	.....	5.00	20.00
Cost 100 sq. yds.....	35.0		$.....		$286.61
Cost per sq. yd.....			.....		2.87

Cost of 100 Sq. Yds. 2" Solid Plaster Partition Applied to Metal Lath Using Pre-Mixed Perlite Plaster (Measurement One Side Only)

Add for metal lath and furring.

Ordinary Workmanship—2" Partition—2" of Plaster

Scratch Coat	Hours	Rate	Total	Rate	Total
15–80-lb. sacks P. Plaster.		$.....	$.....	$2.10	$ 31.50
Plasterer	5	.....	.....	6.50	32.50
Labor	5	.....	.....	5.00	25.00
Brown Coat					
70–80-lb. sacks P. Plaster.		.....	.....	2.10	147.00
Plasterer	23	.....	.....	6.50	149.50
Labor	17.0	.....	.....	5.00	85.00
Finish White Coat					
680 lbs. fin. hydrated lime		.....	.....	2.40	16.32
340 lbs. gauging plaster...		.....	.....	2.00	6.80
Plasterer	16.0	.....	.....	6.50	104.00
Labor	8.0	.....	.....	5.00	40.00
Cost 100 sq. yds.....	74.0		$.....		$637.62
Cost per sq. yd.....			.....		6.38

Machine Application of Plaster.—Various types of machines are available for the spray application of base coat plaster mortar to walls and ceilings where it is then worked in the normal manner. They vary in size from large machines capable of spraying any plaster mortars, including base coat materials for ordinary plastering and membrane fireproofing, to small machines which handle only the finish coat of acoustical plaster or a sand float finish. Most models have self-contained pump units with gasoline or electric power air compressors. Several small hand gun-hopper units are available for attachment to separate air compressors.

A large machine, complete with pump, gasoline power air compressor, 50-ft. material hose, base coat nozzle and acoustical or sand float finish nozzle costs approximately $4,300.00 f.o.b. factory—price without air compressor, about $1,800.00. These machines are also available truck mounted or trailer mounted for convenient mobility.

Small units, complete with pump, compressor unit, hand gun-hopper, hose, etc. range in price from $350.00 to $450.00 f.o.b. factory. Separate hand gun-hopper units, including air hose and fittings cost approximately $135.00.

When applying plaster mortars by machine, approximately 20 to 25 percent additional material will be required to provide equal coverage to hawk and trowel application. This is caused

by material densification due to machine action and increased material loss from spattering.

Using the machine method, the labor cost of applying the various plaster coats will be considerably less than for the hawk and trowel method, but an allowance must be made for machine cost and maintenance and additional protection and clean-up labor will be required.

Where scratch coat is machine applied over metal lath, an experienced operator can apply 750 to 850 sq. yds. per 8-hr. day. For this area, an additional 4-hrs. plasterer time will be required for touching up and scratching surface.

Cost of 100 Sq. Yds of Machine Applied Scratch Coat on Metal Lath Using Perlite or Vermiculite Aggregate

Add for metal lath and furring.

	Hours	Rate	Total	Rate	Total
1,200 lbs. gypsum plaster..		$.....	$.....	$1.60	$19.20
24 cu. ft. aggregate.....		.....	.....	.60	14.40
Plasterer	1.5	.....	.....	6.50	9.75
Labor	2.0	.....	.....	5.00	10.00
Machine cost	1.0	.....	.....	2.00	2.00
Cost 100 sq. yds.	3.5		$.....		$55.35
Cost per sq. yd.					.55

Where brown coat is machine applied over scratch coat or gypsum lath, an experienced operator, with another plasterer rodding and leveling, can apply 375 to 425 sq. yds. per 8-hr. day.

Cost of 100 Sq. Yds. of Machine Applied Brown Coat, 7/16" Thick over Scratch Coat or Gypsum Lath, Using Perlite or Vermiculite Aggregate

	Hours	Rate	Total	Rate	Total
1,550 lbs. gypsum plaster..		$.....	$.....	$1.60	$ 24.80
50 cu. ft. aggregate.....		.....	.....	.60	30.00
Plasterer	4	.....	.....	6.50	26.00
Labor	4	.....	.....	5.00	20.00
Machine cost	2	.....	.....	2.00	4.00
Cost 100 sq. yds.	8		$.....		$104.80
Cost per sq. yd.			.....		$1.05

Special Prepared Finishes

There are a number of prepared plaster finishes on the market that are ready for use by the addition of water. These may be applied over a brown coat of gypsum cement plaster and the cost of the material is the only additional cost.

Smooth trowel finishes such as gypsum gauging-lime putty require a much higher degree of rigidity and strength in the lath and basecoat plaster for good visual performance. When the use

of high strength basecoat plasters is impractical, consideration should be given to the elimination of restraint at the perimeter angles or the selection of a more rigid lath, or both. They help to compensate for the lower strength of some basecoat plasters.

Where a special finish is specified, deduct the cost of the finish white coat as given under the ordinary plastering classification and add the cost of the special finish specified.

Cost of 100 Sq. Yds. Gypsum Trowel Finish

Ordinary Workmanship

	Hours	Rate	Total	Rate	Total
550 lbs. gyp. trowel finish..		$.....	$.....	$3.60	$19.80
Plasterer	8	.....	.....	6.50	52.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	12		$.....		$91.80
Cost per sq. yd.			.....		.92

For first grade workmanship, add 3.5 hrs. plasterer time and 1-hr. labor time per 100 sq. yds.

Cost of 100 Sq. Yds. Sand Float Finish

If plaster is wanted with a sand float finish, deduct quantities of plaster and labor given under finish white coat and add the following:

Ordinary Workmanship

	Hours	Rate	Total	Rate	Total
200 lbs. unfibered plaster..		$.....	$.....	$1.80	$ 3.60
4 cu. ft. sand		.....	.....	.17	.68
Plasterer	7.25	.....	.....	6.50	47.13
Labor	5.00	.....	.....	5.00	25.00
Cost per sq. yds.....	12.25		$.....		$76.41
Cost per sq. yd.....			.....		.76

First Grade Workmanship

	Hours	Rate	Total	Rate	Total
750 lbs. prepared finish..		$.....	$.....	$3.00	$22.50
Plasterer	10	.....	.....	6.50	65.00
Labor	6	.....	.....	5.00	30.00
Cost 100 sq. yds.....	16		$.....		$117.50
Cost per sq. yd.			.....		1.18

Cost of 100 Sq. Yds. Keene's Cement Smooth Finish, (Medium Hard) Applied Over a Brown Coat of Gypsum Cement Plaster

Ordinary Workmanship

	Hours	Rate	Total	Rate	Total
530 lbs. Keene's cement..		$.....	$.....	$3.75	$ 19.88
270 lbs. fin. hydrated lime		.....	.....	2.40	6.48
Plasterer	14.5	.....	.....	6.50	94.25
Labor	5.0	....	.....	5.00	25.00
Cost 100 sq. yds.....	19.5		$.....		$145.61
Cost per sq. yd.			.....		1.46

If blocked off into squares to represent tile, add about 16 hrs. plasterer time per 100 sq. yds.

If first grade workmanship is required, add 5.5 hrs. plasterer time and 1-hr. labor time per 100 sq. yds.

Cost of 100 Sq. Yds. Keene's Cement Sand Float Finish

Keene's cement sand float finish coat may be applied over a brown coat of gypsum cement plaster, either plain or blocked off into ashlar effects. If blocked, add extra for this work.

Ordinary Workmanship

	Hours	Rate	Total	Rate	Total
160 lbs. Keene's cement..		$.....	$.....	$3.75	$ 6.00
125 lbs. fin. hydrated lime..		.....	.....	2.40	3.00
6 cu. ft. clean sand.....		.....	.....	.17	1.02
Plasterer	13	.....	.....	6.50	84.50
Labor	6	.....	.....	5.00	30.00
Cost 100 sq. yds.....	19		$.....		$124.52
Cost per sq. yd.			.....		1.25

If first grade workmanship is required, add 4 hrs. plasterer time and 1-hr. labor time per 100 sq. yds.

The resistance of gypsum gauging-lime putty trowel finishes to cracking, particularly to check cracking, can be increased by the addition of fine aggregate. The use of not less than ½ cubic foot of fine silica sand or perlite to each 100 pounds of gauging plaster or Keene's cement, increases the factor of safety in trowel finishes.

Acoustical Plaster.—Acoustical plaster is occasionally specified, in lieu of trowel putty coat or sand float finishes, for noise quieting in classrooms, corridors, etc., and for acoustical correction of churches and auditoriums. A number of prepared acoustical plasters are available having sound absorption values of 40 to 45 percent at 512 cycles and a noise reduction coefficient of 55 to 60 percent.

There are two general types of acoustical plaster. Those with a gypsum or lime binder, such as Sabinite, Hi-Lite, Kilnoise, Gold Bond, Perfolite, etc., are for trowel application only with either a troweled, floated or stippled and perforated finish. Other acoustical plasters, such as Audicote, Sprayolite, Zonolite Acoustical Plaster, etc., are made with an adhesive type binder that shrinks on drying, providing the porosity for sound absorption, and may be applied by machine or trowel.

In general, acoustical plasters are for application over gypsum base coats (scratch and brown) and should be applied in two coats to a total thickness of ½"—usually a ⅜" first coat and a ⅛" finish coat.

Acoustical plasters for trowel application only are usually sold by the square yard, ½" thick, and cost about $1.00 per sq. yd. Acoustical plasters for machine or trowel application are usually sold by the bag (sizes vary considerably), with an estimate of the coverage per bag, and the cost ranges from $2.75 for a 4-sq. yd., ½" thick, bag to $6.00 for a 10-sq. yd., ½" thick bag or 60 to 70 cts. per sq. yd., ½" thick.

Where applied by trowel, a plasterer should complete 65 to 75 sq. yds. of acoustical plaster, two coats to ½" total thickness, per 8-hr. day.

Cost of 100 Sq. Yds. of Acoustical Plaster Applied by Trowel

Add for lath and base coats required.

	Hours	Rate	Total	Rate	Total
20 bags (5 sq. yds., ½" thick), acoustical plaster.		$.....	$.....	$5.50	$110.00
Plasterer	11.5	.....	.....	6.50	74.75
Labor	6.0	.....	.....	5.00	30.00
Cost 100 sq. yds.	17.5		$.....		$214.75
Cost per sq. yd.			.....		2.15

Where application of the two coat acoustical finish is by machine, a plasterer should complete 100 to 110 sq. yds. per 8-hr. day, but one extra hour of labor time must be figured for the additional cleanup and protection required, and an allowance included for cost and maintenance of equipment.

Cost of 100 Sq. Yds. of Acoustical Plaster Applied by Machine

Add for lath and base coats required.

	Hours	Rate	Total	Rate	Total
14 bags (7.2 sq. yds. ½" thick) acoustical plaster		$.....	$.....	$5.50	$77.00
Plasterer	8.0	.....	.....	6.50	52.00
Labor	7.0	.....	.....	5.00	35.00
Machine cost	7.5	.....	.....	3.00	22.50
Labor (masking)	7.0	.....	.....	5.00	35.00
Cost per 100 sq. yds.	29.5		$.....		$221.50
Cost per sq. yd.			.....		2.22

Vermiculite Direct-to-Steel Fireproofing.—Vermiculite Type-MK direct-to-steel fireproofing is a new and economical method of protecting steel columns, beams, girders, and trusses, and steel floor and roof sections. It is applied by machine directly to the metal, without a primer, lath, or reinforcing. It presents a tough, fire-protective and insulating coating free of fissures, and can be

applied in the early stages of construction when the building is free of other trades.

This is a mill-mixed material that requires only the addition of water. It is packaged in 25- and 50-pound bags.

Coverage varies with specified thickness. The cost is about 25¢ per bd. ft.

Colored Interior Finish Plaster

There are a number of colored finish plasters on the market used for textured or float plaster finish.

These special finishes are applied over a brown coat of gypsum cement plaster and may be finished in a number of different ways, such as Spanish Palm Finish, Brush Swirl, Float Finish, English Trowel finish, etc., as shown in the accompanying illustrations, in addition to a simple float finish.

Labor Applying Special Finish Coats.—For colored finish plaster with a simple float finish, a plasterer should apply 100 to 120 sq. yds. per 8-hr. day, where an ordinary grade of workmanship is permitted, and 70 to 90 sq. yds. per 8-hr. day where first grade workmanship is required.

For textured finishes, the costs will vary depending upon the type of finish desired and the artistry of the mechanic, but an experienced man should apply 60 to 70 sq. yds. of finish coat per 8-hr. day.

Oriental* Interior Color Finish Plaster.—Used for textured or floated plaster finish. It is made in 13 standard shades and white and is ready for use with the addition of water only.

It requires approximately 8 lbs. of Oriental finish per sq. yd. depending upon the texture used. Price about $65.00 per ton.

Cost of 100 Sq. Yds. of Oriental* Interior Colored Finish Plaster, with Simple Float Finish, Applied Over a Brown Coat of Gypsum Cement Plaster

Ordinary Workmanship

Finish Coat	Hours	Rate	Total	Rate	Total
800 lbs. Oriental finish..		$.....	$.....	$3.50	$28.00
Plasterer	7.25	.....	.....	6.50	47.13
Labor	4.50	.....	.....	5.00	22.50
Cost 100 sq. yds.....	11.75		$.....		$97.63
Cost per sq. yd.....			.....		.98

If first grade workmanship is required, add 2.75 hrs. plasterer time and 1-hr. labor time per 100 sq. yds.

*United States Gypsum Company.

Colored Plaster with Smooth or Textured Finish

	Rate	Total	Rate	Total
350 lbs. Keene's cement..	$.....	$.....	$3.75	13.13
450 lbs. fin. hydrated lime..	.....	.....	2.40	10.80
16 lbs. color	.....	.....	.40	6.40
Cost 100 sq. yds.....		$.....		$30.33
Cost per sq. yd. (material only)		.....		.30

Colored Plaster with Sand Float Finish

	Rate	Total	Rate	Total
100 lbs. Keene's cement..	$.....	$.....	$3.75	$ 3.75
500 lbs. fin. hydrated lime..	.....	.....	2.40	12.00
1,200 lbs. white silica sand	.....	.....	.52	6.24
36 lbs. color	.....	.....	.40	14.40
Cost 100 sq. yds.....		$.....		$36.39
Cost per sq. yd. (material only)		.....		.36

The above formulas are standard mixture for permanent colors. Best results are obtained by soaking lime overnight or 24 hours.

ORNAMENTAL PLASTERING

Ornamental plastering is not used as extensively as it once was, and mechanics who can do this type of work are not always available. It is best to contact a plastering subcontractor for firm prices for intricate ornamental plaster work.

Cost of 100 Lin. Ft. of Plaster Cornice Under 12" in Girth

	Hours	Rate	Total	Rate	Total
200 lbs. gypsum plaster..		$.....	$.....	$1.60	$ 3.20
4 cu. ft. sand.....		.....	.....	.17	.68
50 lbs. molding plaster..		.....	.....	3.00	1.50
Plasterer	18	.....	.....	6.50	117.00
Labor	6	.....	.....	5.00	30.00
Cost 100 lin. ft.....	24		$.....		$152.38
Cost per lin. ft.....					1.52

Add for metal lath and furring as given on previous pages.

Cost of 100 Sq. Ft. of Ornamental Plaster Cornice Over 1'-0" in Girth

	Hours	Rate	Total	Rate	Total
200 lbs. gypsum plaster..		$.....	$.....	$1.60	$ 3.20
4 cu. ft. sand.....		.....	.....	.17	.68
50 lbs. molding plaster..		.....	.....	3.00	1.50
Plasterer	17	.....	.....	6.50	110.50
Labor	6	.....	.....	5.00	30.00
Cost 100 sq. ft.....	23		$.....		$145.88
Cost per sq. ft.....			.....		1.46

Add for metal lath and furring as given on previous pages.

Figure 50 to 65 cts. per lin. ft. for each row of ornamental plaster enrichment.

Cost of 100 Sq. Ft. of Portland Cement Cornice

	Hours	Rate	Total	Rate	Total
4 sacks portland cement		$.....	$.....	$1.80	$ 7.20
40 lbs. hydrated lime..		.....	.....	2.40	.96
10 cu. ft. sand.....		.....	.....	.17	1.70
Plasterer	46	.....	.....	6.50	299.00
Labor	10	.....	.....	5.00	50.00
Cost 100 sq. ft.....	56		$.....		$358.86
Cost per sq. ft.....					3.59

Add for metal lath and furring as given on previous pages.

Figure $1.00 per lin. ft. for each row of ornamental enrichment.

Running Bull Nose Corners, Ceiling Coves, Etc.—When running bull nose corners on plaster columns, pilasters, window jambs, etc., and plain ceiling coves and wall angles, where just an ordinary grade of workmanship is required and it is not necessary to plumb the work to show the same margin throughout, a plasterer should run 80 to 100 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Plasterer	9	$.....	$.....	$6.50	$58.50
Labor	2	.....	.....	5.00	10.00
Cost 100 lin. ft.....	11		$.....		$68.50
Cost per lin. ft.....					.69

Where first grade workmanship is required with all angles and corners absolutely straight and plumb and all door and window reveals showing exactly the same margin, a plasterer should run 60 to 70 lin. ft. of bull nose corner or ceiling cove per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Plasterer	12.5	$.....	$.....	$6.50	$81.25
Labor	3.0	.....	.....	5.00	15.00
Cost 100 lin. ft.....	15.5		$.....		$96.25
Cost per lin. ft.....			.....		.96

PORTLAND CEMENT PLASTER

Portland cement plaster is used for both interior and exterior work. It should not be mixed too rich, as too rich a mixture has a tendency to check and shrink.

Proper attention to curing is important. After each coat has set, and before the following coat is applied the mortar should be kept moist for at least three days, and then permitted to dry out gradually.

When using portland cement mortar it is customary to add a small percentage of lime (usually about 10%) to make the mortar work easier, as a straight portland cement mortar is very difficult to apply.

For the cost of portland cement plaster applied over metal lath and the cost of metal lath and furring see previous pages of this chapter.

Labor Applying 100 Sq. Yds. Portland Cement Plaster to Various Plaster Bases

Description of Work Ordinary Work*	No. Sq. Yds. per 8-Hr. Day	Hrs. 100 Sq. Yds. Plasterer	Laborer
Interior Work on Brick, Clay Tile or Cement Block—¾" Thick			
Scratch Coat	120-140	6	4
Brown Coat	75- 85	10	5
Float Finish Coat	60- 70	12	4
Trowel Finish Coat	45- 55	16	4
Interior Portland Cement Plaster on Metal Lath			
Scratch Coat	120-140	6	5
Brown Coat	60- 70	12	6
Float Finish Coat	60- 70	12	4
Trowel Finish Coat	45- 55	16	4
Exterior Portland Cement Stucco on Brick, Clay Tile or Cement Block			
Scratch Coat	120-140	6	5
Brown Coat	75- 85	10	6
Scaffold			12
Exterior Portland Cement Stucco on Metal Lath on Frame Construction			
Scaffold			12
Scratch Coat	120-140	6	6
Brown Coat	60- 70	12	8
Floated Finish Coat	60- 70	12	6
Troweled Finish Coat	45- 55	16	6
Textured Finish Coat	50- 60	14	6
Blocking Off Portland Cement Plaster into Squares to Represent Tile	45- 55	16	4
Portland Cement Straight Base	45- 55**	16	4
Portland Cement Coved Base	30- 35**	24	6

*For first grade workmanship as described at the beginning of this chapter, add 30 to 40 percent to plasterer time for brown and finish coats. **Lineal feet.

Cost of 100 Sq. Yds. 2-Coat Portland Cement Plaster on Brick, Clay Tile or Cement Block

Ordinary Workmanship—⅝" Grounds

Brown Coat	Hours	Rate	Total	Rate	Total
14 sacks portland cement.		$.....	$.....	$1.80	$ 25.20
140 lbs. hydrated lime....		.....	.....	2.40	3.36
42 cu. ft. sand.....		.....	.....	.17	7.14
Plasterer	13	.....	.....	6.50	84.50
Labor	6	.....	.....	5.00	30.00
Finish Coat					
4 sacks portland cement..		.....	.....	1.80	7.20
40 lbs. hydrated lime....		.....	.....	2.40	.96
12 cu. ft. sand.....		.....	.....	.17	2.04
Plasterer	16	.....	.....	6.50	104.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	39		$.....		$284.40
Cost per sq. yd.....			.....		2.84

Cost of 100 Sq. Yds. 3-Coat Portland Cement Plaster on Brick Clay Tile or Cement Block

Ordinary Workmanship—⅝" Grounds

Scratch Coat	Hours	Rate	Total	Rate	Total
6 sacks portland cement		$.....	$.....	$1.80	$ 10.80
60 lbs. hydrated lime....		.....	.....	2.40	1.44
18 cu. ft. sand.....		.....	.....	.17	3.06
Plasterer	6	.....	.....	6.50	39.00
Labor	4	.....	.....	5.00	20.00
Brown Coat					
8 sacks portland cement..		.....	.....	1.80	14.40
80 lbs. hydrated lime....		.....	.....	2.40	1.92
24 cu. ft. sand.....		.....	.....	.17	4.08
Plasterer	10	.....	.....	6.50	65.00
Labor	5	.....	.....	5.00	25.00
Finish Coat					
4 sacks portland cement..		.....	.....	1.80	7.20
40 lbs. hydrated lime.....		.....	.....	2.40	.96
12 cu. ft. sand		.....	.....	.17	2.04
Plasterer	16	.....	.....	6.50	104.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.....	45		$.....		$318.90
Cost per sq. yd.....			.....		3.19

If first grade workmanship is required, add 8 hrs. plasterer time and 2 hrs. labor time per 100 sq. yds.

If blocked off into squares to represent tile, add 16 hrs. plasterer time for ordinary work and 18 hrs. plasterer time for first grade workmanship per 100 sq. yds.

Cost of 100 Sq. Yds. 3-Coat Portland Cement Plaster on Metal Lath

Add for metal lath and furring.

Ordinary Workmanship—¾" Grounds

Scratch Coat	Hours	Rate	Total	Rate	Total
7 sacks portland cement		$.....	$.....	$1.80	$ 12.60
70 lbs. hydrated lime		.....	.....	2.40	1.68
21 cu. ft. sand		.....	.....	.17	3.57
Plasterer	6	.....	.....	6.50	39.00
Labor	5	.....	.....	5.00	25.00
Brown Coat					
11 sacks portland cement		.....	.....	1.80	19.80
110 lbs. hydrated lime		.....	.....	2.40	2.64
33 cu. ft. sand		.....	.....	.17	5.61
Plasterer	12	.....	.....	6.50	78.00
Labor	6	.....	.....	5.00	30.00
Finish Coat					
4 sacks portland cement		.....	.....	1.80	7.20
40 lbs. hydrated lime		.....	.....	2.40	.96
12 cu. ft. sand		.....	.....	.17	2.04
Plasterer	16	.....	.....	6.50	104.00
Labor	4	.....	.....	5.00	20.00
Cost 100 sq. yds.	49		$.....		$352.10
Cost per sq. yd.			.....		3.52

If blocked off into squares to represent tile, add 16 hrs. plasterer time per 100 sq. yds.

If ⅝" grounds are used instead of ¾", deduct 2 sacks portland cement, 20 lbs. lime and 6 cu. ft. sand.

If first grade workmanship is required, add 8 hrs. plasterer time and 2 hrs. labor time per 100 sq. yds.

Cost of 100 Lin. Ft. of 6" Portland Cement Straight Base

	Hours	Rate	Total	Rate	Total
2 sacks portland cement		.....	.....	$1.80	$ 3.60
20 lbs. hydrated lime		.....	.....	2.40	.48
6 cu. ft. sand		.....	.....	.17	1.02
Plasterer	16	.....	.....	6.50	104.00
Labor	4	.....	.....	5.00	20.00
Cost 100 lin. ft.	20		$.....		$129.10
Cost per lin. ft.			.....		1.29

For coved base, add 50 percent to material and labor.

If cement finishers are used on this work, allow the same number of hours as given for plasterers.

EXTERIOR STUCCO

Exterior stucco is generally composed of a portland cement base. The scratch and brown coats should be mixed in the proportions of 1 part of portland cement by weight to 3 parts of clean sand by weight. Do not add more than 8 lbs. of lime to each 100 lbs. of portland cement used in the mixture.

Portland cement plaster should not be applied when the outside temperature is below 32° F. as freezing is injurious to portland cement.

The cost of portland cement stucco will vary according to the materials used and the grade of workmanship required.

Applying Scratch Coat of Portland Cement Stucco.—Where just an ordinary grade of workmanship is required, a plasterer should apply 120 to 140 sq. yds. of scratch coat per 8-hr. day.

Applying Brown Coat of Portland Cement Stucco.—A plasterer should apply 75 to 85 sq. yds. of brown coat per 8-hr. day, on brick, tile or concrete block walls and 60 to 70 sq. yds. per 8-hr. day on metal lath.

Applying Trowel Finish Coat of Portland Cement.—A plasterer should apply 45 to 55 sq. yds. of portland cement trowel finish per 8-hr. day, where just an ordinary grade of workmanship is required and 35 to 40 sq. yds. per 8-hr. day, where first grade workmanship is required.

Applying Wet Rough Cast Finish to Portland Cement Stucco.—If a wet rough cast finish is used and the mortar and aggregate are thrown against the wall with a paddle or similar tool, a plasterer should complete 30 to 40 sq. yds. per 8-hr. day.

Applying Pebble Dash or Dry Rough Cast.—When applying a pebble dash or dry rough cast finish where the aggregate is thrown against the wet cement or "butter" coat, a plasterer should apply 35 to 40 sq. yds. per 8-hr. day.

Washing Exterior Stucco With Acid to Expose Crystals.—Where the finish coat of stucco contains granite, marble or crystal screenings, it is washed off with a solution of muriatic acid to expose the crystals. A man should wash 475 to 525 sq. ft. (53 to 58 sq. yds.) per 8-hr. day.

On some jobs it will be necessary to wash the walls two or three times to bring out the crystals satisfactorily, and in such instances the labor cost should be increased accordingly.

A solution of commercial muriatic acid in the proportion of 1:10 (1 part acid to 10 parts water) should be used.

Cost of 100 Sq. Yds. 3-Coat 1:3 Portland Cement Stucco, Float Finish, Applied to Metal Lath Over Wood Framing

Add for metal lath.

	Ordinary Workmanship				
	Hours	Rate	Total	Rate	Total
Labor-Scaffold	12	$.....	$.....	$5.00	$ 60.00
Scratch Coat—1:3					
8 sacks portland cement		.....	.....	1.80	14.40
60 lbs. hydrated lime		.....	.....	2.40	1.40
24 cu. ft. sand		.....	.....	.17	4.08
Plasterer	6	.....	.....	6.50	39.00
Labor	6	.....	.....	5.00	30.00
Brown Coat—1:3					
16 sacks portland cement		.....	.....	1.80	28.80
120 lbs. hydrated lime		.....	.....	2.40	2.88
48 cu. ft. sand		.....	.....	.17	8.16
Plasterer	12	.....	.....	6.50	78.00
Labor	8	.....	.....	5.00	40.00
Float Finish—1:3					
5 sacks w'p'f. portland cement		.....	.....	2.00	10.00
15 cu. ft. sand		.....	.....	.17	2.55
Plasterer	12	.....	.....	6.50	78.00
Labor	6	.....	.....	5.00	30.00
Cost 100 sq. yds.	62		$.....		$427.27
Cost per sq. yd.					4.27

If a smooth troweled finish is desired, add 4 hrs. plasterer time.

If a textured finish coat is desired, add 2 hrs. plasterer time.

If first grade workmanship is required, add 8 hrs. plasterer time to the above.

Cost of 100 Sq. Yds. 3-Coat 1:3 Portland Cement Stucco, Float Finish, Applied Over Brick, Clay Tile or Concrete Block Surfaces

	Ordinary Workmanship				
	Hours	Rate	Total	Rate	Total
Labor—Scaffold	12	$.....	$.....	$5.00	$ 60.00
Scratch Coat—1:3					
6 sacks portland cement		.....	.....	1.80	10.80
45 lbs. hydrated lime		.....	.....	2.40	1.08
18 cu. ft. sand		.....	.....	.17	3.06
Plasterer	6	.....	.....	6.50	39.00
Labor	5	.....	.....	5.00	25.00
Carried Forward	23		$.....		$138.94

Cost of 100 Sq. Yds. 3-Coat 1:3 Portland Cement Stucco, Float Finish, Applied Over Brick, Clay Tile or Concrete Block Surfaces—(Continued)

	Hours	Rate	Total	Rate	Total
Brought Forward	23	$.....	$.....	$....	$138.94
Brown Coat					
10 sacks portland cement		.....	.....	1.80	18.00
75 lbs. hydrated lime		.....	.....	2.40	1.80
30 cu. ft. sand		.....	.....	.17	5.10
Plasterer	10	.....	.....	6.50	65.00
Labor	6	.....	.....	5.00	30.00
Float Finish					
5 sacks w'p'f. portland cement		.....	.....	2.00	10.00
15 cu. ft. sand		.....	.....	.17	2.55
Plasterer	12	.....	.....	6.50	78.00
Labor	6	.....	.....	5.00	30.00
Cost 100 sq. yds.	57		$.....		$379.39
Cost per sq. yd.			.....		3.79

For smooth troweled finish, add 4 hrs. plasterer time.

If a textured finish coat is desired, add 2 hrs. plasterer time.

If first grade workmanship is required, add 8 hrs. plasterer time to the above.

Special Finishes for Portland Cement Stucco

If any of the following special finishes are wanted with portland cement stucco, deduct the finish coat given above and add cost of the finish coat desired.

Cost of 100 Sq. Yds. of White Cement Float Finish

Ordinary Workmanship	Hours	Rate	Total	Rate	Total
5 sacks w'p'f. white cement		$.....	$.....	$4.50	$ 22.50
1,500 lbs. white silica sand.		.....	.....	.60	9.00
Plasterer	12	.....	.....	6.50	78.00
Labor	6	.....	.....	5.00	30.00
Cost 100 sq. yds.	18		$.....		$139.50
Cost per sq. yd.			.....		1.39

Cost of 100 Sq. Yds. Finish Coat Colored Stucco, Float Finish

Ordinary Workmanship	Hours	Rate	Total	Rate	Total
2 sacks w'p'f. white cement		$.....	$.....	$4.50	$ 9.00
100 lbs. fin. hydrated lime		.....	.....	2.40	2.40
600 lbs. white silica sand		.....	.....	.60	3.60
18 lbs. color		.....	.....	.40	7.20
Plasterer	12	.....	.....	6.50	78.00
Labor	6	.....	.....	5.00	30.00
Cost 100 sq. yds.	18		$.....		$130.20
Cost per sq. yd.			.....		1.30

If a smooth troweled finish is desired, add 4 hrs. plasterer time.

If a textured finish is desired, add 2 hrs. plasterer time.

If first grade workmanship is required, add 8 hrs. plasterer time to the above.

Cost of 100 Sq. Yds. Wet Rough Cast Finish Coat

	Hours	Rate	Total	Rate	Total
4 sacks w'p'f. portland cement		$.....	$.....	$2.10	$ 8.40
12 cu. ft. sand.....		.....	.....	.17	2.04
500 lbs. aggregate.....		.....	.....	3.00	15.00
Plasterer	20	.....	.....	6.50	130.00
Labor	10	.....	.....	5.00	50.00
Cost 100 sq. yds.....	30		$.....		$205.44
Cost per sq. yd.....					2.05

Cost of 100 Sq. Yds. of Dry Rough Cast Finish

	Hours	Rate	Total	Rate	Total
4 sacks w'p'f. portland cement		$.....	$.....	$2.10	$ 8.40
12 cu. ft. sand.....		.....	.....	.17	2.04
750 lbs. aggregate.....		.....	.....	3.00	22.50
Plasterer	20	.....	.....	6.50	130.00
Labor	10	.....	.....	5.00	50.00
Cost 100 sq. yds.....	30		$.....		$212.94
Cost per sq. yd.....			.....		2.13

A dry rough cast finish requires a finish or "butter" coat $\frac{1}{4}$" thick applied directly over the brown coat. This is brought to a straight, smooth finish and then the aggregate is thrown onto the "butter" coat dry.

If coarse aggregate is used, it requires about 1,000 lbs. per 100 sq. yds.

If medium size aggregate is used, it requires 750 lbs. per 100 sq. yds.

If fine aggregate is used, it requires 500 lbs. per 100 sq. yds.

APPROXIMATE PRICES ON LATHING AND PLASTERING MATERIALS

Metal Lath

Description	Finish	Wt. Lbs. Sq. Yd.	Price Sq. Yd.
Expanded diamond mesh (flat)	Painted	2.5 lbs.	$0.50
Expanded diamond mesh (flat)	Painted	3.4 lbs.	.60
Expanded diamond mesh (flat)	Galvanized	3.4 lbs.	.70

Self-furring lath, add 2 cts. per sq. yd. to the above prices.

Rib Metal Lath

Description	Finish	Height of Rib	Wt. Lbs. Sq. Yd.	Price Sq. Yd.
Flat rib lath	Painted	1/8"	2.75	$0.65
Flat rib lath	Painted	1/8"	3.4	.75
Rib or rod ribbed lath	Painted	3/8"	3.4	.75
Rib or rod ribbed lath	Painted	3/8"	4.0	.86

Hot Rolled Channels

Width	Leg	Weight per 1,000 Ft.	Price per 1,000 Lin. Ft.
3/4" Standard	15/32"	300	$ 38.00
1 " Standard	1/2"	410	53.00
1 1/2" Standard	19/32"	650	78.00
2 " Standard	7/16"	1,260	142.00

Perforating, add $1.00 per 1,000 ft.

Cold Rolled Channels

Width	Leg	Weight per 1,000 Ft.	Price per 1,000 Lin. Ft.
3/4"	1/2"	300 lbs.	$ 52.00
1 1/2"	19/32"	475 lbs.	78.00
2"	19/32"	590 lbs.	111.00

Wire

16 Ga.	$0.20 per ln. ft.
18 Ga.	0.22 " " "

Studs & Tracks

Size	Per 1,000 Ln. Ft.
1 5/8"	$111.00
2 1/2"	112.00
3 1/4"	118.00
4 "	132.00
6 "	186.00
Shoes	$31.00 per 1,000 pcs.

Approximate Prices of Lathing and Plastering Materials—Continued

Corner Bead

Type	Per 1,000 Ln. Ft.
Regular	$73.00
Expanded	95.00
Bull Nose	90.00
Cornerite	40.00

Rods

	Price per 1,000 Lin. Ft.
3/16" plain	$18.00
3/16" galvanized	18.00
1/4" plain	18.00
1/4" galvanized	18.00
3/8" plain	80.00

Gypsum Lath

Description	Price per 1,000 sq. ft.
Gypsum lath, plain or perforated, 16"x48"x3/8"	$52.00
Gypsum lath, foilback, 16"x48"x3/8"	61.00
Gypsum lath, plain, 16"x48"x1/2"	60.00
Gypsum lath, foilback, 16"x48"x1/2"	72.50
Gypsum lath, long length, 24"x96"x1/2"	63.00

Nails and Staples

Description	Price per 100 Lbs.
Gypsum lath, 1 1/8" blued	$16.50
Gypsum lath, 1 1/4" blued	16.50
Roofing, barbed, 1 1/4" galv.	19.00
Concrete stub	38.50
Annular ring nail (blued)	45.00
Brick—plain 2" and 2 1/2"	24.00

Plastering Items

Asbes. Cem. Fibers	$ 0.10 Per Lb.
Liquid Bonding Agent	10.50 Per Gal.

Gypsum Plaster

	Per 100 Lbs.
Gypsum Cement Plaster	$1.60
Wood Fiber (prepared)	1.60
Bondcrete (for concrete)	1.80

Lime and Finishing Plaster

	Per 100 Lbs.
Pulverized Quickline	$2.10
Plasterer's Hydrated Lime	2.40
Gypsum Gauging Plaster	1.80
No. 1 Molding Plaster	3.00
Keene's Cement, Regular or Fast	3.75
Portland Cement	1.80

Prepared Finishes

Hair (4 Lb. to Bu.)	$3.00 Per Bu.
Fiber (2 Lb. to Bu.)	$3.00 Per Bu.

	Per 100 Lbs.
Perlite Plaster	$ 2.00
Gypsum Trowel Finish	3.60
Silica Sand Float	3.75
Acoustical Plaster	11.00

CHAPTER XIX

PAINTING AND DECORATING

Estimates and bids on painting and interior decorating vary to a greater extent than almost any other branch of building construction, and when one looks into the matter it is not surprising because carelessness in taking off the quantities from the plans is a fault common to painters. Then too, there are several kinds of painters—good painters, fair painters, poor painters and others who are just plain "daubers." There are painters who figure on "skinning the job" by applying one or two fewer coats of paint or varnish than called for by the specifications; others who figure on substituting cheap and inferior materials for those called for; and others who do not know how to do good work, so naturally one should expect a wide variation in figures.

Of course, a cheap or inferior job costs less than a first class job, and the buyer usually gets what he pays for.

When preparing estimates on painting, consider the quality of materials and workmanship required and price the work accordingly.

METHODS OF MEASURING AND LISTING PAINTING QUANTITIES

When estimating quantities of painting or interior finishing, the actual surface to be painted should be measured as accurately as possible from the plans or from measurements taken at the building. From these measurements it should be possible to estimate the quantity of materials required, but the labor quantities present a much more difficult problem, owing to the different classes of work and the difficulties encountered in applying the paint. For instance, the covering capacities of paint will be the same for a plain surface or a cornice, but the labor cost painting the cornice will be considerably more owing to the height of the cornice above the ground and the amount of "cutting" or "trimming" necessary. Care must be used when pricing any piece of work, as conditions on each job are different.

Clapboard or Drop Siding Walls.—Obtain actual area of all walls and gables. Add 10 percent to actual surface measurement to allow for painting under edge of boards. Do not deduct for openings less than 10′-0″x10′-0″.

Shingle Siding.—Obtain actual area of all walls and gables and multiply by 1½. Do not deduct for openings less than 10′-0″x 10′-0″.

Brick, Wood, Stucco, Cement and Stone Walls.—Obtain actual area of all walls and gables. Do not deduct for openings less than 10′-0″x10′-0″.

Eaves.—Plain eaves painted same colors as side walls, obtain area and multiply by 1½. If eaves are painted a different color than side walls, obtain area and multiply by 2.

Eaves with rafters running through, obtain area and multiply by 3.

Eaves over brick, stucco or stone walls, obtain area and multiply by 3.

For eaves over 30′-0″ above ground, add ½ for each additional 10′-0″ in height.

Cornices, Exterior.—Plain cornices, obtain area and multiply by 2. Fancy cornices or cornices containing dentils, etc., obtain area and multiply by 3.

Downspouts and Gutters.—Plain downspouts and gutters, measure the area and multiply by 2. For fancy downspouts and gutters, obtain area and multiply by 3.

Blinds and Shutters.—Plain blinds or shutters, measure one side and multiply by 2. Slatted blinds or shutters, measure one side and multiply by 4.

Columns and Pilasters.—Plain columns or pilasters, obtain area in sq. ft.; if fluted, obtain area and multiply by 1½; if paneled, obtain area and multiply by 2.

Lattice Work.—Measure one side and multiply by 2 if painted one side only; if painted two sides, obtain area and multiply by 4.

Porch Rail, Balustrade, Balusters.—If solid balustrade, add one foot to height to cover top and bottom rail. Multiply the length by the height. If painted two sides, multiply by 2.

If balustrade consists of individual balusters and handrail, multiply length by the height, then multiply the result by 4.

Handrail only. If under 1′-0″ girth, figure as 1′-0″ by length and multiply by 2.

Moldings.—Cut in on both sides, figure 1 sq. ft. per lin. ft. if under 12" girth. If over 12" girth, take actual measurement.

Doors and Frames, Exterior.—Inasmuch as it costs almost as much to paint a small door as a large one, do not figure any door less than 3'-0"x7'-0". Allowing for frame, add 2'-0" to the width and 1'-0" to the height. For instance, a 3'-0"x7'-0" door would be figured as 5'-0"x8'-0" or 40 sq. ft.

If a sash door, containing small lights of glass, add 2 sq. ft. for each additional light. A 4-lt. door would contain 8 sq. ft. additional; a 12-lt. door, 24 sq. ft. additional, etc.

If painted on both sides, obtain sq. ft. area of one side and multiply by 2.

Door frames only, where no door is hung, allow area of opening to take care of both sides.

Windows, Exterior.—Inasmuch as it costs almost as much to paint a small window as a large one, do not figure any window less than 3'-0"x6'-0". Add 2'-0" to both the width and height of the opening, to take care of the sides and head of the frame and the outside casing or brick mold, and multiply to obtain the area. For instance, a window opening 3'-0"x6'-0", add 2'-0" to both the width and height, making 5'-0"x8'-0", containing 40 sq. ft. of surface.

If sash contain more than one light each, such as casement sash, etc., add 2 sq. ft. for each additional light. A 6-lt. window would contain 12 sq. ft. additional; a 12-ft. window, 24 sq. ft. additional, etc.

Roofs.—For flat roofs or nearly flat, measure actual area. For roofs having a quarter pitch, measure actual area and add 25 percent; roofs having a one-third pitch, measure actual area and add 33⅓ percent; roofs having a half pitch, measure actual area and add 50 percent.

Fences.—Plain fences, measure one side and multiply by 2; picket fences, measure one side and multiply by 4.

Picture Mold and Chair Rail.—On picture mold, chair rail, etc., less than 6" wide, obtain the number of lin.ft. to be painted or varnished and figure ¾ sq. ft. per lin. ft.

Wood and Metal Base.—Wood or metal base under 1'-0" high should be figured as 1'-0" high.

Wood Panel Strips, Cornices, Etc.—When estimating quantities of wood panel strips, wainscot rail and ceiling cornices, measure the girth of the member and if less than 1'-0" wide, figure as 1'-0".

If over 1′-0″ wide, multiply the actual girth by the length, viz., 1′-3″x200′-0″=250 sq. ft.

Refer to rule for exterior cornices.

Interior Doors, Jambs and Casings.—When estimating quantities for interior doors, jambs and casings, add 2′-0″ to the width and 1′-0″ to the height of the opening. This allows for painting or varnishing the edges of the door, the door jambs which are usually 6″ wide, and the casings on each side of the door which average from 4″ to 6″ wide. Example: On a 3′-0″x7′-0″ door opening, add 2′-0″ to the width and 1′-0″ to the height, which gives an opening 5′-0″x8′-0″, containing 40 sq. ft. on each side. Some painters figure all single doors at 40 sq. ft. per side, or 80 sq. ft. for both sides, while others figure them at 50 sq. ft. per side or 100 sq. ft. for both sides. Do not deduct for glass in doors.

If a sash door, containing small lights of glass, add 2 sq. ft. for each additional light. A 4-lt. door would contain 8 sq. ft. additional; a 12-lt. door, 24 sq. ft. additional, etc.

Interior Windows, Jamb Linings, Sash and Casings.—When estimating painting quantities for windows and window trim, add 2′-0″ to the sides and length to allow for jamb linings, casing at the top and sides, and window stool and apron at the bottom. Example: If the window opening is 3′-0″x6′-0″, adding 2′-0″ to both the width and length gives a window 5′-0″x8′-0″, containing 40 sq. ft. of surface.

If sash contain more than one light each, such as casement sash, etc., add 2 sq. ft. for each additional light. A 6-lt. window would contain 12 sq. ft. additional; a 12-lt. window, 24 sq. ft. additional, etc.

Stairs.—When estimating quantities of paint or varnish for wood stairs, add 2′-0″ to the length of treads and risers to allow for stair strings on each side of the stairs. A stair tread is 10″ to 12″ wide, riser is about 7″ high, and the average cove and underside of a stair tread 2″ in girth, so each tread should be figured 2′-0″ wide. Multiply the width by the length to obtain the number of sq. ft. of paint or varnish required for each step. Multiply the area of each step by the number of treads in the stair, and the result will be the number of sq. ft. of finish. Example: A flight of stairs containing 20 treads, 4′-0″ long. Adding 2′-0″ to the length of the treads to allow for the stringers, gives 6 lin. ft. in each tread, which, multiplied by the girth of 2′-0″ gives 12 sq. ft. of surface in each step. Since there are 20 treads in the stairs, 12×20=240 sq. ft.

For painting the soffits of stairs, use same rules of measurement as given above.

Balustrades and Handrails with Balusters.—When estimating balustrades around well holes or stair handrail and balusters, measure the distance from the top of the treads to the top of the handrail and add 6″ for painting or varnishing the handrail. Multiply the height of the balustrade by the length and the result will be the number of sq. ft. of balustrade. An easy method for computing the length of the stairs is to allow 1 lin. ft. in length for each tread in the stairs. Example: If the handrail is 2′-6″ above the treads and the stairs contain 20 treads, add 6″ to the height of 2′-6″ to take care of the extra work on the handrail proper, making a total height of 3′-0″. 3×20=60 sq. ft. of surface for one side of the balustrade or 120 sq. ft. for two sides.

The balustrade around the stair well hole is easily estimated by multiplying the height by the length.

On fancy balustrades having square or turned spindles which require considerable additional labor, use actual measurements as given above and multiply by 4 to allow for extra labor.

Wood Ceilings.—When estimating quantities for wood ceilings, multiply the length by the width. Do not deduct for openings less than 10′-0″x10′-0″.

Wainscoting.—Plain wainscoting, obtain actual area. Paneled wainscoting, obtain actual area and multiply by 2.

Floors.—To compute the quantities of floors to be finished, multiply the length of each room by the width, and the result will be the number of sq. ft. of floor to be finished.

Plastered Walls and Ceilings.—To obtain the area of any ceiling, multiply the length by the breadth, and the result will be the number of sq. ft. of ceiling.

When estimating walls, measure the entire distance around the room and multiply by the room height. The result will be the number of sq. ft. of wall to be decorated. For instance, a 12′-0″x15′-0″ room has two sides 12′-0″ long and two sides 15′-0″ long, giving a total of 54 lin. ft. If the ceilings are 9′-0″ high, 54×9=486 sq. ft. the area of the walls.

Do not deduct for door and window openings.

Cases, Cupboards, Bookcases, Etc.—When estimating surfaces of cupboards, wardrobes, bookcases, closets, etc., to be painted or varnished, obtain the area of the front and multiply by 3 if the cases do not have doors.

If the cases have doors, obtain the area of the front and multiply by 5.

This takes care of painting or varnishing doors inside and out, shelves 2 sides, cabinet ends and backs.

Radiators.—For each front foot, multiply the face area by 7.

Sanding and Puttying Interior Trim.—Sanding and puttying on high grade interior trim should be figured as one coat of paint or varnish; on medium grade trim, figure at 50 percent of one coat of paint or varnish. For industrial work, figure about 25 percent of the cost of one coat of paint or varnish.

COVERING CAPACITY OF PAINTS

It is difficult to say how many sq. ft. of surface one gallon of paint will cover, as there are several items that influence the covering capacity. By brushing the paint out very thin it will cover more surface than when applied thick. Dark paint will hide the surface better than light paint, and for that reason it can be brushed out thinner than the lighter colors. Also, a rough surface will require considerable more paint than a smooth surface.

Soft and porous wood will absorb more oil and require more paint than close grained lumber.

Another thing that must be considered are the ingredients entering into the paint. Different brands of paint vary in covering capacity or hiding power.

Covering Capacity of Oil Base Paint on New Exterior Wood.—In figuring the number of square feet a gallon of oil base paint will cover, a great deal depends upon the surface to be painted; that is, the kind of wood, the degree of roughness, etc. Some woods are more porous than others and absorb more paint. Much depends on the way the paint is brushed out as some painters brush the paint out more and thus cover more surface.

The priming coat, properly applied, should cover 450 to 500 sq. ft. per gallon. The second coat should cover 500 to 550 sq. ft. per gallon and the third coat should cover 575 to 625 sq. ft. per gallon.

When estimating exterior trim painting, with measurements taken in accordance with standard methods as given on previous pages, the priming coat should cover 750 to 850 sq. ft. per gallon;

the second coat should cover 800 to 900 sq. ft. per gallon and the third coat should cover 900 to 1,000 sq. ft. per gallon.

Bear in mind the above coverages are based on surfaced lumber, as the covering capacity will be greatly reduced when applied to rough boards.

Painting Old Exterior Wood Surfaces.—When estimating repaint work on old exterior wood surfaces, if the existing surface is sound and in good condition, two coats should be sufficient to give a good job and paint coverages should be about the same as for the second and third coats on similar new work.

If the old surface shows cracking, blistering, scaling and peeling, the old paint should be removed by using either a paste or liquid paint remover of the slow drying type, or a blow torch and scraper.

If the old paint is removed completely, three coats of paint should be applied the same as recommended for new work.

Painting Wood Shingle Siding.—Wood shingle siding should receive three coats of paint on new work. Paint coverages per gallon should be as follows: first coat, 300 to 325 sq. ft.; second coat, 400 to 450 sq. ft.; third coat, 500 to 550 sq. ft.

Wood shingles which have been previously painted with an oil paint and are in suitable condition for repainting, should receive two coats of paint. The first coat should cover 400 to 450 sq. ft. per gal. and the second coat 500 to 550 sq. ft. per gal.

Painting Exterior Wood Floors and Steps.—When painting exterior wood floors and steps with oil base paint, material coverages per gallon should be as follows: first coat, 325 to 375 sq. ft.; second coat, 475 to 525 sq. ft.; third coat, 525 to 575 sq. ft.

Painting Interior Wood.—New interior wood should receive three coats of paint, a priming coat, a second coat and a final or finish coat.

Paint coverage for interior wood surfaces will vary with the type of work, such as doors and windows, running trim, paneling, etc., in accordance with the standard method of measuring the quantities.

For doors and windows, coverage per gallon should be: first coat, 575 to 600 sq. ft.; second coat, 475 to 500 sq. ft.; third coat, 500 to 550 sq. ft.

For running trim up to 6" wide, coverage per gallon should be: first coat, 1,100 to 1,200 lin. ft.; second and third coats, 800 to 900 lin. ft.

For ordinary flat wood paneling, coverage per gallon should be: first coat, 500 to 550 sq. ft.; second and third coats, 450 to 500 sq. ft.

When painting interior woodwork that has been previously painted and is in good condition, one gallon of paint should cover approximately the same as given for the second and third coats on new wood.

Painting Brick, Stone, Stucco and Concrete.—When painting masonry surfaces that are reasonably smooth, one gallon of oil base paint should cover 170 to 200 sq. ft. for the priming coat; 350 to 400 sq. ft. for the second coat and 375 to 425 sq. ft. for the third coat.

These quantities are subject to considerable variation due to the porosity of the surfaces to which the paint is applied, smoothness of walls, etc., as a rough porous surface will require considerably more paint than a smooth hard surface.

Painting Metal Work.—The area which any paint may be expected to cover on metal work will vary with the surface to be painted as badly pitted or rough metal will require more paint than a perfectly smooth surface. The covering capacity will also vary with the temperature, consistency of the paint and the effort behind the brush.

However, for ordinary smooth surfaces, one gallon of paint should cover 550 to 650 sq. ft., one coat.

Aluminum Paint.—Aluminum paint is used for both priming and finishing coats on metal surfaces.

The covering capacity varies with the condition of the surface but on smooth surfaces, one gallon should cover 600 to 700 sq. ft. with one coat.

Painting Interior Walls.—When painting interior walls, the covering capacity of the paint will depend upon the surface to be painted, whether smooth or sand finished plaster, porous or hard finished wallboard, etc.

Three coats are recommended for interior plaster which has never been painted—a priming coat, a second or body coat, and a third or finishing coat.

However, if a two coat job on unpainted plaster is desired, use a good wall primer or sealer for the first coat, followed by the second or finishing coat. To make two coats hide better, tint the first coat to nearly the same color as the second coat.

If the surface has been painted before and the old paint is still in good condition, two coats are sufficient, no priming coat being required.

On smooth plaster or hard finished wallboard, one gallon of good wall primer or sealer should cover 575 to 625 sq. ft. for the priming coat. For the second coat, figure 500 to 550 sq. ft. per gallon and for the third coat, 575 to 625 sq. ft. per gallon.

On rough, porous sand finished plaster, one gallon of wall primer or sealer may cover only 275 to 300 sq. ft. while on very porous wall board it may be only 150 to 200 sq. ft. per gallon.

For the second and third coats on rough surfaced plaster or wallboard, figure 400 to 475 sq. ft. per gallon.

One Coat Wall Finishes.—There are any number of "one-coat" wall finishes on the market, but when applied to new plastered surfaces or over surfaces that have been previously unpainted, it is advisable to use a primer or wall seal coat, which seals the pores in the plaster or other surface and provides a base suitable to receive the one coat finish. Fully described above.

Latex Base Paints.—There are any number of latex base paints on the market that are compatible to most surfaces.

When used over smooth plastered surfaces, one gallon should cover 450 to 500 sq. ft. first coat and 550 to 650 sq. ft. second coat.

When applied over rough sand finish plaster one gallon should cover 325 to 350 sq. ft. per coat.

Covering Capacity of Wall Size.—The covering capacity of wall size will vary greatly with the material used.

Water size consisting of ground or flake glue and water will cover 600 to 700 sq. ft. of surface per gallon.

Varnish size consisting of varnish, benzine or turpentine and a little paint, will cover 450 to 500 sq. ft. per gallon.

Hard oil or gloss oil size consisting of rosin and benzine will cover 450 to 500 sq. ft. per gallon.

The covering capacity of prepared wall primers and sealers is given on the previous pages under "Painting Interior Walls."

Shingle Stain.—When staining wood shingles after they have been laid, one gallon of good stain should cover 120 to 150 sq. ft. of surface, for the first coat.

The second and third coats will go farther, as the wood does not absorb as much stain as on the first coat and should cover 200 to 225 sq. ft. per gallon.

One gallon of good stain should cover about 70 sq. ft. of roof with 2-coats or 50 sq. ft. with 3 coats.

If the shingles are dipped in stain before laying, it will require 3 to 3½ gals. of stain per 1,000 shingles. When dipping shingles in stain, only two-thirds of the shingle need be dipped, as it is unnecessary to dip the end of the shingle that is not exposed.

Covering Capacity of Oil and Spirit Stains.—When staining finishing lumber, such as birch, mahogany, oak, gum, etc., one gallon of oil stain should cover 700 to 725 sq. ft.

One gallon of spirit stain should cover 500 to 600 sq. ft.

Covering Capacity of Wood Fillers.—Liquid filler is usually

used with close grained woods, such as pine, birch, etc., and one gallon should cover 500 to 550 sq. ft.

It is necessary to use a paste filler to fill the pores of all open grained wood, such as oak, ash, walnut, mahogany, etc.

If paste filler is used on oak, one gallon of filler should cover about 450 sq. ft. of surface.

Covering Capacity of Shellac.—The covering capacity of shellac will vary with its purity but one gallon of good shellac should cover 550 to 750 sq. ft. of surface, depending upon whether first, second or third coat.

Covering Capacity of Varnish.—One gallon of good varnish should cover 400 to 450 sq. ft. of softwood floors with one coat; 200 to 225 sq. ft. with 2 coats and 135 to 150 sq. ft. with 3 coats.

When applied to hardwood floors, one gallon of good varnish should cover 500 to 550 sq. ft. with one coat; 250 to 275 sq. ft. with 2 coats and 170 to 185 sq. ft. with 3 coats.

When applied to softwood interior finish, one gallon of good spar finishing varnish should cover 400 to 425 sq. ft. with one coat; 200 to 215 sq. ft. with 2 coats and 135 to 145 sq. ft. with 3 coats.

When applied to hardwood interior finish, one gallon of good spar finishing varnish should cover 425 to 450 sq. ft. with one coat; 210 to 225 sq. ft. with 2 coats and 140 to 150 sq. ft. with 3 coats.

Covering Capacity of Wax.—One gallon of good liquid wax should cover 1,050 to 1,075 sq. ft. of surface.

Covering Capacity of Varnish Remover.—The amount of varnish remover required to remove old varnish from floors and interior finish will depend upon the condition of the old work, but one gallon of good varnish remover should be sufficient for 150 to 180 sq. ft. of surface.

Enamel Finish.—Where interior woodwork is to receive an enamel finish, at least three coats are required, as follows: first coat, oil base paint primer and sealer; second coat, prepared enamel undercoat; third coat, enamel finish coat. If a four-coat job is specified, the third coat may be a mixture of ½ undercoat and ½ enamel, followed by the enamel finish coat.

For flat work, figure material coverages per gallon as follows: paint primer and sealer, 575 to 600 sq. ft.; undercoat, 375 to 400 sq. ft.; enamel finish, 475 to 500 sq. ft.

For running trim, one gallon of material should cover as follows: paint primer and sealer, 1,100 to 1,200 lin. ft.; undercoat, 775 to 800 lin. ft.; enamel finish, 775 to 800 lin. ft.

Glazed Finish.—One gallon of good glazing liquid, colored with oil colors, should cover 500 to 550 sq. ft. of surface.

For glazed finish on interior running trim, not over 6" wide, one gallon should cover 1,050 to 1,100 lin. ft.

ESTIMATING LABOR COSTS

Perhaps in no other trade will labor costs vary to a greater extent than in painting and decorating. On some classes of work the material costs are almost negligible, while the labor costs may make it one of the most expensive kinds of work.

Naturally, the cost of the work will depend upon the grade of workmanship specified or upon the class of work the painting contractor figures on doing.

In the large cities particularly, there are two classes of painters—those who make a specialty of ordinary or commercial work such as factory buildings, flat or apartment buildings, speculative work and work of this class, and those who specialize in high class work. Naturally, the painter who figures the lower grade of workmanship is bound to be lower than the man who figures a first class job, as a painter can cover more surface per day when he just hits the "high spots" than when he is concientious in his work and gives a good, honest job.

When preparing an estimate, the estimator should consider the class of work required and price his work accordingly.

Another thing that must be borne in mind by the estimator, is to be certain all measurements and quantities are listed and computed in strict accordance with the "Rules for Measurement" as given at the beginning of this Chapter.

This applies particularly to the allowances for labor when estimating such items as sash doors, windows having divided lights, drop siding and shingle siding, fences, trellis and lattice work where the face and edges of all surfaces must be painted, stairs where it is necessary to paint all four sides or the entire circumference of newels, handrails, balusters, etc.

These are all exceedingly important because if the quantities are not computed according to the methods given, then the labor costs will be far too low in many instances—in other words, "You get the job—but who gets the profit?"

The costs as given on the following pages are based on the methods of estimating quantities as given at the beginning of this chapter.

ITEMIZED COSTS OF PAINTING

The itemized costs given on the following pages include the specifications generally called for by architects and owners and furnish the contractor or estimator detailed information regarding every item entering into the cost of any class of painting. These costs are tabulated in such a way that local material prices and wage scales may be substituted in all instances.

To compute the cost of paint in any locality, refer to the itemized costs given on the previous pages and insert local prices.

The following costs include sufficient material for the superficial area figured. If there are many large openings, the quantity of paint may be reduced, depending upon the number and size of openings.

Painting Contractor's Overhead Expense and Profit.—Inasmuch as the painting on a building is usually sublet to a painting contractor, it will be necessary to add for the painting contractors overhead expense and profit.

The direct and indirect job expense include social security and unemployment compensation tax, contributions to employees welfare fund, compensation insurance, public liability and property damage, allowance for brushes, sponges, etc., loss of tools and equipment, laundering and wear and tear on dropcloths, ladders, scaffolding, wiping rags, truck expense, etc. This will vary from 20 to 25 percent of the direct labor cost.

In addition, there will be the general overhead, including rent, light and heat, telephone, postage, stationery, office help, estimating service, association dues, traveling expense, salaries, etc. This will vary from 10 to 15 percent, depending upon the volume of work and the individual contractor's setup. Then, too, there is the little item of profit, which may vary from 10 to 15 percent.

Labor and Materials Required for Various Painting Operations

EXTERIOR WORK—RESIDENTIAL Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Sanding and Puttying Plain Siding and Trim		200–210	0.50	.....
Sanding and Puttying Outside Trim Only		115–120	0.86	.....
Burning Paint off Plain Surfaces		40–50	2.20	.....
Burning Paint off Wood Siding		30–40	2.85	.....
Exterior Brush Painting Plain Siding and Trim	Priming Coat	100–110	0.95	400–450
	Second Coat	115–125	0.85	500–550
	Third Coat	125–135	0.75	575–625
Exterior House Painting Rubberized Woodbond	One Coat	125–135	0.75	450–500
Exterior Trim Only	Priming Coat	65–75	1.40	750–850
	Second Coat	85–95	1.12	800–900
	Third Coat	95–105	1.00	900–1,000
Oil Paint—Shingle Siding*	First Coat	115–125	0.82	250–300
	Second Coat	150–160	0.65	375–425
Oil Paint—Shingle Roofs*	First Coat	100–120	0.90	120–150
	Second Coat	155–175	0.60	220–250
Stain—Shingle Siding*	First Coat	75–85	1.20	120–150
	Second Coat	115–130	0.82	200–225
Stain—Shingle Roofs*	First Coat	145–155	0.67	100–120
	Second Coat	190–210	0.50	170–200
*If surfaces are exceptionally dry, increase labor hours and decrease covering capacity.				
Asbestos Wall Shingles	First Coat	60–70	1.50	150–180
	Second Coat	85–95	1.11	350–400
Brick Walls, Oil Paint	First Coat	100–120	0.93	170–200
	Second Coat	140–160	0.67	350–400
	Third Coat	155–175	0.60	375–425
Porch Floors and Steps, Oil Paint	First Coat	235–245	0.42	325–375
	Second Coat	270–280	0.36	475–525
	Third Coat	285–295	0.35	525–575

Labor and Materials Required for Various Painting Operations—Con't.

EXTERIOR WORK—RESIDENTIAL Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Waterproof Cement Paint—Smooth Face Brick	First Coat	175-185	0.55	90–110
	Second Coat	260–270	0.38	140–160
Clear Waterproof Paint—Smooth Face Brick	First Coat	200–210	0.50	500–510
	Second Coat	200–210	0.50	590–610
Stucco, Medium Texture, Oil Paint	First Coat	90–100	1.10	140–160
	Second Coat	150–160	0.65	340–360
	Third Coat	150–160	0.65	340–360
Stucco, Medium Texture, Wpf. Cement Paint	First Coat	130–140	0.74	. 90–110
	Second Coat	190–210	0.50	125–145
Exterior Masonry, Stucco, Asbestos Cement Board and Shingle Siding— Rubberized Flat Finish	First Coat	100–120	0.91	325–375
	Second Coat	165–175	0.59	375–425
Concrete Walls, Smooth, Wpf. Cement Paint	First Coat	170–180	0.57	110-130
	Second Coat	275–285	0.36	150–170
Concrete Floors and Steps—Floor Enamel	First Coat	250–280	0.38	440–460
	Second Coat	190–210	0.50	575–625
	Third Coat	200-220	0.48	575–625
Cement Floors—Color Stain and Finish	First Coat	350-370	0.28	475–525
	Second Coat	280–300	0.35	450–500
Fences, Plain, Average	First Coat	125–135	0.77	450–470
	Second Coat	190–200	0.51	530–550
Fences, Picket, Average	First Coat	140–150	0.70	630–650
	Second Coat	160–170	0.60	650–675
Fences, Wire-Metal, Average	First Coat	100–110	0.95	900–1,000
	Second Coat	140–150	0.70	975–1,125
Shutters, Average, Each Coat	No. of Shutters	2–3	0.40	11–13
Downspouts and Gutters, Paint	First Coat	170–180	0.57	540–560
	Second Coat	185–195	0.53	575–600
Screens, Wood Only, Average, Each Coat	No. of Screens	6–8	0.14	45–55
Storm Sash, 2 Light, Average, Each Coat	No. of Sash	3–4	0.29	23–27

Labor and Material Required For Commercial and Industrial Painting

Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Exterior Work from Swing Scaffold	Each Coat	60–65	1.60	575–625
Sheet Metal Work	First Coat	230–240	0.43	500–550
	Second Coat	260–270	0.38	550–600
Steel Factory Sash	First Coat	80–90	1.18	950 1,000
For Old Work, add 10 to 20 percent to Prepare Surfaces	Second Coat	100–110	0.95	950 1,000
	Third Coat	125–135	0.77	1,250–1,350
Doors and Windows, Paint	First Coat	175–185	0.55	550–600
	Second Coat	130–140	0.75	450–500
	Third Coat	165–175	0.60	500–550
Base, Chair Rail, Picture Mold, and Other Trim Less than 6″ Wide. Lin. Ft.*	First Coat	275–300*	0.35*	1,100–1,200*
	Second Coat	175–200*	0.55*	850 900*
	Third Coat	150–165*	0.65*	850–900*
On most commercial and industrial work, a painter will perform 10 to 15 percent more work than		given in the	tables on the	previous pages.
Masonry Walls—Bonding and Penetrating Oil Paint	First Coat	350–360	0.28	225–250
	Second Coat	350–375	0.28	275–300
Waterproofing—Common Brick, Smooth Brick, Concrete, Concrete or Cinder Concrete Blocks, Cement Plaster	First Coat	100–110	1.00	90–100
	Second Coat	180–195	0.53	175–200
Water proofing Wire Cut Tapestry Brick or Very Rough Cinder Conc Block or Stucco	First Coat	90–100	1.05	50 60
	Second Coat	150–165	0.65	150–175

* Lineal Feet

Spray Painting—Commercial Work

Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Flat Finish Paint—Smooth Plaster Walls	First Coat	460–475	0.22	500 550
	Second Coat	400–425	0.24	500–550
Sand Finish Plaster Walls	First Coat	365–390	0.27	450–500
	Second Coat	325–350	0.30	400–450
Industrial Enamel—Smooth Finish Plaster	First Coat	450–475	0.22	500–550
	Second Coat	400–425	0.25	400–450
	Third Coat	350–375	0.28	450–500
Spray Gun Stipple	After Walls have been Sized and Painted	125–150	0.73	350–375

Spray Painting—Residential Work

Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Brick, Tile and Cement—Cement Water Paint	First Coat	265–275	0.37	90 110
	Second Coat	325–350	0.30	140–160
Brick, Tile and Cement—Oil Paint	First Coat	240–260	0.40	250-275
	Second Coat	240–260	0.40	400 450
Brick, Tile and Cement—Synthetic Resin Bound Exterior Paint	First Coat	275 290	0.36	125–150
	Second Coat	335–360	0.30	175–200
Rough Brick, Tile, Cement and Stucco*—Plastic Paint	One Coat	265–275	0.37	65–75
Asbestos Wall Shingles*	First Coat	100–110	1.00	150–175
	Second Coat	150–175	0.60	225–250
Stucco*—Exterior Cement Water Paint or Synthetic Resin Bound Exterior Paint	First Coat	200 225	0.47	90-100
	Second Coat	265–285	0.37	125–150
Stucco*—Oil Paint	First Coat	160–175	0.60	200 225
	Second Coat	225–240	0.43	350 400
Shingle Roofs—Oil Paint	First Coat	260–275	0.37	125–150
	Second Coat	260 275	0.37	200-225
Shingle Roofs—Stain	First Coat	275–300	0.35	125 150
	Second Coat	275–300	0.35	200-225
Shingle Siding*—Oil Paint	First Coat	160 175	0.60	125 150
	Second Coat	175 200	0.55	225 250
Shingle Siding*—Stain	First Coat	175–200	0.55	125-150
	Second Coat	190–215	0.50	200 225

*Trim Must be Figured Separately as Hand Work

Labor and Material Required For Interior Painting and Finishing

FINISHING INTERIOR TRIM—RESIDENTIAL Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Preparatory Work for Painting	Sanding	290-300	0.35	.....
	Sanding and Puttying	190 200	0.50	.....
	Light Sanding	340 350	0.30	.....
Back Priming Interior Trim Up to 6″ Wide	Lin. Ft.*	475-500*	0.21*	1,100 1,200*
Doors and Windows, Painting Interior	First Coat	140–150	0.70	575 600
	Second Coat	115-125	0.85	475-500
	Third Coat	115–125	0.85	500–550
Oiling or Priming Wood Sash	No. of Sash	9–10	0.10	600–700
Base, Chair Rail, Picture Mold, and Other Trim Up to 6″ Wide. All Quantities are in Lineal Feet	First Coat	250–260*	0.40*	1,100-1,200*
	Second Coat	165-175*	0.60*	800 900*
	Third Coat	140 150*	0.70*	800-900*
Preparatory Work for Enamel Finishes	Sanding	290 300	0.35	.....
	Sanding and Puttying	120-130	0.80	.....
	Light Sanding	135-145	0.72	.....
Doors and Windows, Enamel Finish	Paint First Coat	140–150	0.70	575–600
	Undercoat Second Coat	90–100	1.10	375-400
	Enamel Third Coat	100–110	1.00	475 500
Four Coat Work. Add ½ Underc. ½ Enamel	Add'l Coat	90–100	1.10	425-450
Base, Chair Rail, Picture Mold, and Other Trim Up to 6″ Wide. All Quantities are in Lineal Feet	First Coat	250–260*	0.40*	1,100-1,200*
	Second Coat	145-155*	0.67*	775–800*
	Third Coat	125 135*	0.77*	775–800*
Four Coat Work. Add ½ Underc. ½ Enamel	Add'l Coat	135 145*	0.72*	775 800*
Stain Interior Woodwork	One Coat	215 225	0.45	700–725
Stain and Fill Interior Woodwork, Wipe Off	One Coat	65–70	1.50	400 450
Shellac Interior Woodwork	One Coat	215-225	0.45	700-725
Varnish, Gloss, Interior Woodwork	One Coat	165–175	0.60	425 450
Varnish, Flat, Interior Woodwork	One Coat	170 180	0.57	600–625
Wax and Polish Standing Trim	One Coat	100-110	0.95	550–600
Penetrating Stainwax—Standing Trim	First Coat	170 180	0.57	525-550
	Second Coat	190 200	0.51	600–625
	Polishing Second Coat	190 200	0.51	....

* Lineal Feet

Labor and Material Required For Interior Painting and Finishing—Con't.

FINISHING INTERIOR TRIM—RESIDENTIAL Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Sanding for Extra Fine Varnish Finish	Sanding	40–45	2.25	.....
Synthetic Resin Finish, Requires Wiping	First Coat	190–200	0.50	550–600
	Second Coat	210 220	0.47	625 675
Spackling or Swedish Putty over Flat Trim	One Coat	60–65	1.60	140–150*
Glazing and Wiping over Enamel Trim	One Coat	60–65	1.60	1,050–1,100
Brush Stippling Interior Trim, Painted		85–90	1.15	.....
Flat Varnishing and Brush Stippling over Glazed Trim	Varnish	170–180	0.57	600–625
	Stipple	240–250	0.42	.....
OLD WORK				
Washing Average Enamel Finish	Washing	85–90	1.15	.....
Washing Better Grade Enamel Finish	Washing	60–65	1.60	.....
Polishing Better Grade Enamel Finish	Polish	170–180	0.57	1,700 1,800
Removing Varnish with Liquid Remover	Flat Surfaces	30–35	3.00	150–180
Wash, Touch Up, One Coat Varnish	Wash-Touch Up	165–175	0.60	.....
	Varnish	100–110	0.95	575–600
Wash, Touch Up, One Coat Enamel	Wash-Touch Up	140 150	0.70	.....
	Enamel	70–75	1.40	375–400
Wash, Touch Up, One Coat Undercoat and	Wash-Touch Up	140–150	0.70	.....
One Coat Enamel	Undercoat	75–85	1.25	475 500
	Enamel	75 85	1.25	475–500
Burning Off Interior Trim		20–25	4.00	.....
Burning Off Plain Surfaces		30–35	3.00	.....

On most commercial and industrial work, a painter will perform 10 to 15 percent more work than given in the above table.

* Per Lb.

Labor and Material Required For Interior Floors

Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Painting Wood Floors	First Coat	290–300	0.35	525 550
	Second Coat	260–270	0.38	425–450
Filling Wood Floors, Wiping	Fill-Wipe	170–180	0.57	425–450
Penetrating Stainwax—Hardwood Floors	First Coat	390 400	0.25	525-550
	Second Coat	480 490	0.21	600-625
Floor Seal	First Coat	490–500	0.20	600–625
	Second Coat	590–600	0.17	1,200-1,250
Shellac	First Coat	390-400	0.25	500-550
	Second Coat	475 500	0.21	650-675
Stainfill, 1 Shellac, 1 Varnish	Stainfill	260-270	0.38	475–500
	Shellac	390–400	0.25	650–675
	Varnish	300–310	0.33	500–550
Stainfill, 1 Shellac, Wax and Polish	Stainfill	260 270	0.38	475–500
	Shellac	390 400	0.25	650 675
	Wax-Polish	200-210	0.50	1,050–1,075
Varnish, each Coat over Shellac	Varnish	300–310	0.33	500–550
Buffing Floors—by Machine	Buffing	390-400	0.25	
Waxing over 2 Coats of Seal and Polish	Wax-Polish	200–210	0.50	1,050–1,075
Waxing Linoleum—Same as Above				
Linoleum—Varnishing	Varnish	300–310	0.33	500–550
OLD WORK				
Removing Varnish with Liquid Remover	Flat Surfaces	40–45	2.20	170–180
Clean, Touch Up and Varnish	Clean-Touch Up	125 135	0.77	
	Varnish	300 310	0.33	525-550
Clean, Touch Up, Wax and Polish	Clean-Touch Up	125 135	0.77	
	Wax-Polish	200–210	0.50	1,050-1,075

Labor and Material Required For Painting Interior Walls

Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Taping, Beading, Spotting Nail Heads and Sanding Gypsum Wallboard		90–110	1.00	.....
Texture over Gypsum Wallboard	One Coat	250–270	0.39	8–10*
Casein or Resin Emulsion over Textured Gypsum Wallboard	One Coat	300–320	0.32	325 350
Sizing New Smooth Finish Walls	Sizing	350 400	0.27	600–700
Wall Sealer or Primer on Smooth Walls	Sealer	200–225	0.45	575–625
Wall Sealer or Primer on Sand Finish Walls	Sealer	125–135	0.80	275 300
Smooth Finish Plaster—Flat Finish	Sealer	200 225	0.45	575–625
	Second Coat	165–175	0.60	500–550
	Third Coat	175–185	0.55	575–625
	Stippling	190 200	0.52	.....
Sand Finish Plaster, Flat Finish	Sealer	125 135	0.80	275–300
	Second Coat	135–145	0.70	400–450
	Third Coat	125–135	0.80	425–475
Smooth Finish Plaster, Gloss or Semi-Gloss	Sealer	200–225	0.45	575 625
	Second Coat	170–180	0.57	500–550
	Third Coat	140–150	0.70	500–550
	Stippling	85–95	1.10	.....
Sand Finish Plaster, Gloss or Semi-Gloss	Sealer	125–135	0.80	275 300
	Second Coat	115–125	0.83	375–400
	Third Coat	125–135	0.80	400–450
Texture Plaster, Average, Semi-Gloss	Sealer	100 110	0.95	250–275
	Second Coat	115–125	0.83	325–350
	Third Coat	125–135	0.80	375–400
Smooth Finish Plaster—Latex Rubber Paints	First Coat	140–160	0.67	300–350
	Second Coat	140–160	0.67	300 350
Sand Finish or Average Texture Plaster—Latex Rubber Paints	First Coat	110 130	0 83	250 300
	Second Coat	110–130	0.83	250–300
Glazing and Mottling over Smooth Finish Plaster		80–90	1.15	1,050–1,075
Glazing and Mottling over Sand Finish Plaster		60–65	1.60	875–900
Glazing and Highlighting Textured Plaster		80–90	1.15	825–850
Starch and Brush Stipple over Painted-Glazed Surface		115–125	0.83	.....

* Per Lb.

Labor and Material Required For Painting Interior Walls—Con't.

Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Flat Varnish and Brush Stipple over Painted-Glazed Surface		105–115	0.90	500–550
Texture Oil Paint over Smooth Finish Plaster	Size	215–225	0.45	675–725
	Texture	40–45	2.30	125–150
Water Texture over Smooth Finish Plaster	Size	215–225	0.45	700–725
	Texture	50–55	1.90	85–95
Latex Base Paint, New Smooth Plaster	First Coat	190–200	0.50	500–550
	Second Coat	210–220	0.47	650–700
On Rough Sand Finish Plaster	One Coat	150–160	0.65	325–350
On Cement Blocks	One Coat	135–145	0.70	300 325
On Acoustical Surfaces	One Coat	135–145	0.70	200 225
Casein Paint, over Smooth Finish Plaster	First Coat	270–280	0.37	500–550
	Second Coat	300–310	0.33	500–550
Over Rough Sand Finish Plaster	One Coat	250–260	0.40	325–350
Over Cement Blocks	One Coat	165–175	0.60	300–325
Over Acoustical Surfaces	One Coat	165–175	0.60	200–225
Over Cinder Concrete Blocks	One Coat	125–135	0.77	125–150

When applying paint to walls and ceilings using a roller applicator, increase above quantities 10 to 15 percent and reduce painter time by the same amount.

Labor and Material Required For Painting Interior Walls

OLD WORK Description of Work		Painter No. Sq. Ft. per Hr.	Painter Hours 100 Sq. Ft.	Material Coverage Sq. Ft. per Gal.
Washing off Calcimine—Average Surfaces		115–125	0.83	.....
Washing Smooth Finish Plaster Walls—Average		145–155	0.67	.....
Washing Sand Finish Plaster Walls—Average		100–110	1.00	.....
Washing Starched Surfaces and Restarching, Smooth Surfaces	Washing	145–155	0.67	.....
	Restarching	130–140	0.75	.....
Removing Old Wall Paper—Not Over 3 Layers		65–75	1.45	.....
Washing Off Glue After Removing Paper (including Fixing Average Cracks and Sizing)		125–135	0.77	.....
Cutting Hard Oil or Varnish Size Walls (including Fixing Average Cracks)		125–135	0.77	.....
Cutting Gloss Painted Walls (including Fixing Cracks)		125–135	0.77	.....
Washing, Touch Up, One Coat Gloss Paint to Smooth Plaster Surfaces	Wash-Touch Up	125–135	0.77	.....
	One Coat	125–135	0.77	450–500
Synthetic-Resin Emulsion Paint over Old Painted Walls	One Coat	190–200	0.50	400–425
WALLPAPER, CANVAS, COATED FABRICS, PAPER HANGING, WOOD VENEER				
Canvas Sheeting		50–60	1.82	.....
Coated Fabrics	Single Roll	2–2½	.....	.....
Wallpaper—One Edge Work	Single Roll	3½–4	.....	.....
Wire Edge Work	Single Roll	2½–3	.....	.....
Butt Work	Single Roll	2¼–2¾	.....	.....
Scenic Paper 40″x60″	Single Roll	1–1¼	.....	.....
Wood Veneer	Sq. Ft.	12–13	.....	.....
Lacquer Finish Over Wood Veneer	First Coat	300–310	0.33	275–325
	Second Coat	300–310	0.33	450–500
Penetrating Wax or Synthetic Resin Application over Wood Veneer	First Coat	550–575	0.1 8	550–600
	Second Coat	600–625	0.1	650–675

The percentage for overhead and profit should be added to the costs listed on the following pages.

Cost of Burning Off Paint From 100 Sq. Ft. of Old Siding

	Hours	Rate	Total	Rate	Total
Painter	2.85	$.....	$.....	$6.00	$17.10

Cost of Sanding and Puttying 100 Sq. Ft. Plain Wood Siding and Trim

	Hours	Rate	Total	Rate	Total
Painter	0.5	$.....	$.....	$6.00	$3.00

Cost of Sanding and Puttying 100 Sq. Ft. Outside Trim Only

	Hours	Rate	Total	Rate	Total
Painter	0.86	$.....	$.....	$6.00	$5.16

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat House Paint Applied to Plain Wood Siding and Trim

Priming Coat	Hours	Rate	Total	Rate	Total
0.24 gal. paint		$.....	$.....	$7.00	$ 1.68
Painter	0.95	.....	.....	6.00	5.70
Second Coat					
0.19 gal. paint		.....	.....	7.00	1.33
Painter	0.85	.....	.....	6.00	5.10
Cost 100 sq. ft.	1.80		$.....		$13.81

Cost of 100 Sq. Ft. (1 Sq.) 3-Coat House Paint Applied to Plain Wood Siding and Trim

Priming Coat	Hours	Rate	Total	Rate	Total
0.24 gal. paint		$.....	$.....	$7.00	$ 1.68
Painter	0.95	.....	.....	6.00	5.70
Second Coat					
0.19 gal. paint		.....	.....	7.00	1.33
Painter	0.85	.....	.....	6.00	5.10
Third Coat					
0.17 gal. paint		.....	.....	7.00	1.19
Painter	0.75	.....	.....	6.00	4.50
Cost 100 sq. ft.	2.55	.....	$.....		$19.50

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat House Paint Applied to Exterior Trim Only

	Hours	Rate	Total	Rate	Total
Priming Coat					
0.13 gal. paint		$.....	$.....	$7.00	$ 0.91
Painter	1.40	.....	.....	6.00	8.40
Second Coat					
0.12 gal. paint		.....	.....	7.00	.84
Painter	1.12	.....	.....	6.00	6.72
Cost 100 sq. ft.	2.52		$.....		$16.87

Cost of 100 Sq. Ft. (1 Sq.) 3-Coat House Paint Applied to Exterior Trim Only

Priming Coat	Hours	Rate	Total	Rate	Total
0.13 gal. paint		$.....	$.....	$7.00	$ 0.91
Painter	1.40	.....	.....	6.00	8.40
Second Coat					
0.12 gal. paint		.....	.....	7.00	.84
Painter	1.12	.....	.....	6.00	6.72
Third Coat					
0.11 gal. paint		.....	.....	7.00	.77
Painter	1.00	.....	.....	6.00	6.00
Cost 100 sq. ft.	3.52		$.....		$23.64

Cost of Applying 1-Coat House Paint to One Average Wood Half-Screen (Screen Wire Not Painted)

	Hours	Rate	Total	Rate	Total
0.02 gal. paint		$.....	$.....	$7.00	$0.14
Painter	0.14	.....	.....	6.00	.84
Cost per screen	0.14		$.....		$0.98

For each additional coat, add same as above.

Cost of Applying 1-Coat House Paint to One Average Wood 2-Lt. Storm Sash

	Hours	Rate	Total	Rate	Total
0.04 gal. paint		$.....	$.....	$7.00	$0.28
Painter	0.29	.....	.....	6.00	1.74
Cost per storm sash	0.29		$.....		$2.02

For each additional coat, add same as above.

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat House Paint Applied to Old Wood Surfaces in Good Condition

First Coat	Hours	Rate	Total	Rate	Total
0.19 gal. paint		$.....	$.....	$7.00	$ 1.33
Painter	1.0	.....	.....	6.00	6.00
Second Coat					
0.17 gal. paint		.....	.....	7.00	1.19
Painter	0.8	.....	.....	6.00	4.80
Cost 100 sq. ft.	1.8		$.....		$13.32

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Oil Paint Applied to Brick or Smooth Concrete Surfaces

	Hours	Rate	Total	Rate	Total
0.54 gal. paint		$.....	$.....	$7.00	$3.78
Painter	0.93	.....	.....	6.00	5.58
Cost 100 sq. ft.	0.93		$.....		$9.36

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Oil Paint Applied to Rough Plaster or Stucco Surfaces

	Hours	Rate	Total	Rate	Total
0.67 gal. paint		$.....	$.....	$7.00	$ 4.69
Painter	1.1	.....	.....	6.00	6.60
Cost 100 sq. ft.	1.1		$.....		$11.29

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Oil Paint Applied to Brick or Smooth Concrete Surfaces

First Coat	Hours	Rate	Total	Rate	Total
0.54 gal. paint		$.....	$.....	$7.00	$ 3.78
Painter	0.93	.....	.....	6.00	5.58
Second Coat					
0.27 gal. paint		.....	.....	7.00	1.89
Painter	0.67	.....	.....	6.00	4.02
Cost 100 sq. ft.	1.60		$.....		$15.27

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Oil Paint Applied to Rough Plaster or Stucco Surfaces

First Coat	Hours	Rate	Total	Rate	Total
0.67 gal. paint		$.....	$.....	$7.00	$ 4.69
Painter	1.10	.....	.....	6.00	6.60
Second Coat					
0.29 gal. paint		.....	.....	7.00	2.03
Painter	0.65	.....	.....	6.00	3.90
Cost 100 sq. ft.	1.75		$.....		$17.22

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of Staining 100 Sq. Ft. (1 Sq.) of Wood Shingles with 2 Coats of Shingle Stain

First Coat	Hours	Rate	Total	Rate	Total
0.91 gal. stain		$.....	$.....	$3.50	$ 3.19
Painter	0.67	.....	.....	6.00	4.02
Second Coat					
0.54 gal. stain		.....	.....	3.50	1.89
Painter	0.50	.....	.....	6.00	3.00
Cost 100 sq. ft.	1.17		$.....		$12.10

COMMERCIAL AND INDUSTRIAL PAINTING

Cost of 100 Sq. Ft. (1 Sq.) Exterior Painting Applied From a Swing Scaffold

	Hours	Rate	Total	Rate	Total
0.17 gal. paint		$.....	$.....	$7.00	$ 1.19
Painter	1.6	.....	.....	6.00	9.60
Cost 100 sq. ft.	1.6		$.....		$10.79

Add same as given above for second and third coats.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Oil Paint Applied to Smooth Metal Surfaces

First Coat	Hours	Rate	Total	Rate	Total
0.19 gal. paint		$.....	.....	$ 7.00	$1.33
Painter	0.43	.....	.....	6.00	2.58
Second Coat					
0.18 gal. paint		.....	.....	7.00	1.26
Painter	0.38	.....	.....	6.00	2.28
Cost of 100 sq. ft.	0.81		$.....		$7.45

Cost of 100 Sq. Ft. (1 Sq.) 3-Coat Oil Paint Applied to New Steel Factory Sash

For old work, add 10 to 20 percent to prepare surfaces.

First Coat	Hours	Rate	Total	Rate	Total
0.10 gal. paint		$.....	$.....	$7.00	$ 0.70
Painter	1.18	.....	.....	6.00	7.08
Second Coat					
0.10 gal. paint		.....	.....	7.00	.70
Painter	0.95	.....	.....	6.00	5.70
Third Coat					
0.08 gal. paint		.....	.....	7.00	.56
Painter	0.77	.....	.....	6.00	4.62
Cost 100 sq. ft.	2.90		$.....		$19.36

Refer to "Methods of Measuring . . ." at beginning of chapter.

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of 100 Sq. Ft. (1 Sq.) 3-Coat Oil Paint Applied to New Shingle Siding

First Coat	Hours	Rate	Total	Rate	Total
0.36 gal. paint		$.....	$.....	$7.00	$ 2.52
Painter	0.82	.....	.....	6.00	4.92
Second Coat					
0.25 gal. paint		.....	.....	7.00	1.75
Painter	0.65	.....	.....	6.00	3.90
Third Coat					
0.25 gal. paint		.....	.....	7.00	1.75
Painter	0.65	.....	.....	6.00	3.90
Cost 100 sq. ft.	2.12		$.....		$18.74

For two coat work, omit cost of third coat.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Oil Paint Applied to Old Shingle Siding*

First Coat	Hours	Rate	Total	Rate	Total
0.36 gal. paint		$.....	$.....	$7.00	$ 2.52
Painter	0.90	.....	.....	6.00	5.40
Second Coat					
0.25 gal. paint		.....	.....	7.00	1.75
Painter	0.75	.....	.....	6.00	4.50
Cost 100 sq. ft.	1.65		$.....		$14.17

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Shingle Stain Applied to Shingle Siding*

First Coat	Hours	Rate	Total	Rate	Total
0.77 gal. shingle stain		$.....	$.....	$3.50	$ 2.70
Painter	1.20	.....	.....	6.00	7.20
Second Coat					
0.47 gal. shingle stain		.....	.....	3.50	1.65
Painter	.82	.....	.....	6.00	4.92
Cost 100 sq. ft.	2.02		$.....		$16.47

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Oil Paint Applied to Asbestos Wall Shingles

First Coat	Hours	Rate	Total	Rate	Total
0.61 gal. paint		$.....	$.....	$7.00	$ 4.27
Painter	1.50	.....	.....	6.00	9.00
Second Coat					
0.27 gal. paint		.....	.....	7.00	1.89
Painter	1.11	.....	.....	6.00	6.66
Cost 100 sq. ft.	2.61		$.....		$21.82

*If surfaces are exceptionally dry, increase labor hours and paint quantities.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Waterproof Cement Paint Applied to Smooth Face Brick

First Coat	Hours	Rate	Total	Rate	Total
1 gal. cement paint (5 lbs.)		$.....	$.....	$0.30	$1.50
Painter	0.55	.....	.....	6.00	3.30
Second Coat					
0.67 gal. cement paint (3 lbs.)		.....	.....	.30	.90
Painter	.38	.....	.....	6.00	2.28
Cost 100 sq. ft.....	0.93		$.....		$7.98

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Waterproof Cement Paint Applied to Medium Texture Stucco or Concrete Blocks

First Coat	Hours	Rate	Total	Rate	Total
1 gal. cement paint (5 lbs.)		$.....	$.....	$0.30	$ 1.50
Painter	0.74	.....	.....	6.00	4.44
Second Coat					
0.75 gal. cement paint (3.75 lbs.)		.....	.....	.30	1.13
Painter	0.50	.....	.....	6.00	3.00
Cost 100 sq. ft.	1.24		$.....		$10.07

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Aluminum Paint Applied to Smooth Metal Surfaces

	Hours	Rate	Total	Rate	Total
0.17 gal. aluminum paint		$.....	$.....	$6.00	$1.02
Painter	0.5	.....	.....	6.00	3.00
Cost 100 sq. ft.....	0.5		$.....		$4.02

For second and third coats, figure same as first coat.

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Oil Paint Applied to Smooth Metal Work

	Hours	Rate	Total	Rate	Total
0.17 gal. red lead and oil..		$.....	$.....	$7.00	$1.19
Painter	0.5	.....	.....	6.00	3.00
Cost 100 sq. ft.....	0.5		$.....		$4.19

For second and third coats, figure same as first coat.

Cost of Dipping 1,000 Wood Shingles (5 Bundles) in Shingle Stain Before Shingles are Laid (Shingles Dipped in Bundles)

	Hours	Rate	Total	Rate	Total
3 gals. stain.....		$.....	$.....	$3.50	$10.50
Painter or shingler.....	0.5	.....	.....	6.00	3.00
Cost 1,000 shingles.....	0.5		$.....		$13.50

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of 100 Sq. Ft. (1 Sq.) 3-Coat Lead and Oil Paint Applied to Exterior Doors and Windows

Refer to "Methods of Measuring . . ." at beginning of chapter.

First Coat	Hours	Rate	Total	Rate	Total
0.17 gal. paint		$.....	$.....	$7.00	$ 1.19
Painter	0.55	.....	.....	6.00	3.30
Second Coat					
0.21 gal. paint		.....	.....	7.00	1.47
Painter	0.75	.....	.....	6.00	4.50
Third Coat					
0.19 gal. paint		.....	.....	7.00	1.33
Painter	0.60	.....	.....	6.00	3.60
Cost 100 sq. ft.	1.90		$.....		$15.39

Cost of 100 Lin. Ft. 3-Coat Oil Paint Applied to Wood Trim, 6" or Less in Width

First Coat	Hours	Rate	Total	Rate	Total
0.09 gal. paint		$.....	$.....	$7.00	$ 0.63
Painter	0.35	.....	.....	6.00	2.10
Second Coat					
0.12 gal. paint		.....	.....	7.00	.84
Painter	0.55	.....	.....	6.00	3.30
Third Coat					
0.12 gal. paint		.....	.....	7.00	.84
Painter	0.65	.....	.....	6.00	3.90
Cost 100 lin. ft.	1.55		$.....		$11.61

SPRAY PAINTING — COMMERCIAL WORK

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Casein Paint Applied to Smooth Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.24 gal. casein paint		$.....	$.....	$3.30	$0.79
Painter	0.25	.....	.....	6.00	1.50
Second Coat					
0.24 gal. casein paint		.....	.....	3.30	.79
Painter	0.23	.....	.....	6.00	1.38
Cost 100 sq. ft.	0.48		$.....		$4.46

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Casein Paint Applied to Sand Finish Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.24 gal. casein paint		$.....	$.....	$3.30	$0.79
Painter	0.26	.....	.....	6.00	1.56
Cost 100 sq. ft.	0.26		$.....		$2.35

Spray Painting—Continued

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Casein Paint Applied to Concrete Blocks or Other Porous Masonry

	Hours	Rate	Total	Rate	Total
0.62 gal. casein paint.....		$.....	$.....	$3.30	$2.05
Painter	0.33	.....	.....	6.00	1.98
Cost 100 sq. ft.....	0.33		$.....		$4.03

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Flat Finish Paint Applied to Smooth Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.19 gal. paint		$.....	$.....	$5.25	$1.00
Painter	0.22	.....	.....	6.00	1.32
Second Coat					
0.19 gal. paint		.....	.....	5.25	1.00
Painter	.24	.....	.....	6.00	1.44
Cost 100 sq. ft.....	0.46		$.....		$4.76

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Flat Finish Paint Applied to Sand Finish Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.21 gal. paint		$.....	$.....	$5.25	$1.10
Painter	0.27	.....	.....	6.00	1.62
Second Coat					
0.24 gal. paint		.....	.....	5.25	1.26
Painter	.30	.....	.....	6.00	1.80
Cost 100 sq. ft.....	0.57		$.....		$5.78

Cost of 100 Sq. Ft. (1 Sq.) 3-Coat Industrial Enamel Applied to Smooth Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.19 gal. primer		$.....	$.....	$4.20	$0.80
Painter	0.22	.....	.....	6.00	1.32
Second Coat					
0.24 gal. undercoat		.....	.....	4.20	1.01
Painter	.25	.....	.....	6.00	1.50
Third Coat					
0.21 gal. enamel		.....	.....	4.75	1.00
Painter	.28	.....	.....	6.00	1.68
Cost 100 sq. ft.....	0.75		$.....		$7.31

INTERIOR ENAMEL WORK

Cost of Sanding and Preparing 100 Sq. Ft. (1 Sq.) Interior Trim Before First Coat

	Hours	Rate	Total	Rate	Total
Painter	0.35	$....	$.....	$6.00	$2.10

Cost of Sanding and Puttying 100 Sq. Ft. (1 Sq.) Interior Enamel Trim Between Coats

	Hours	Rate	Total	Rate	Total
Painter	0.80	$.....	$.....	$6.00	$4.80

Cost of Light Sanding 100 Sq. Ft. (1 Sq.) Interior Enamel Trim Between Coats

	Hours	Rate	Total	Rate	Total
Painter	0.72	$.....	$.....	$6.00	$4.32

Cost of 100 Sq. Ft. (1 Sq.) 4-Coat Enamel Applied to Interior Doors, Windows, Cases, Etc.

First Coat	Hours	Rate	Total	Rate	Total
0.17 gal. primer		$.....	$.....	$4.20	$ 0.71
Painter	0.70	.....	.....	6.00	4.20
Second Coat					
0.26 gal. undercoater		.....	.....	4.20	1.09
Painter	1.10	.....	.....	6.00	6.60
Third Coat					
0.11 gal. undercoater		.....	.....	4.20	.46
0.11 gal. enamel		.....	.....	8.00	.88
Painter	1.10	.....	.....	6.00	6.60
Fourth Coat					
0.21 gal. enamel		.....	.....	8.00	1.68
Painter	1.00	.....	.....	6.00	6.00
Cost 100 sq. ft.	3.90		$.....		$28.22

For preparatory work and sanding between coats, add as given above.

For three coat work, omit cost of third coat.

For each additional coat, add same as fourth coat.

Cost of 100 Lin. Ft. 4-Coat Enamel Applied to Base, Chair Rail and Other Trim Less Than 6 Inches in Width

First Coat	Hours	Rate	Total	Rate	Total
0.09 gal. primer		$.....	$.....	$4.20	$0.38
Painter	0.40	.....	.....	6.00	2.40
Second Coat					
0.13 gal. undercoater		.....	.....	4.20	.55
Painter	.67	.....	.....	6.00	4.02
Carried Forward	1.07		$.....		$7.35

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of 100 Lin. Ft. 4-Coat Enamel Applied to Base, Chair Rail and Other Trim Less Than 6 Inches in Width—Continued

	Hours	Rate	Total	Rate	Total
Brought Forward	1.07	$.....	$.....	$....	$ 7.35
Third Coat					
0.06 gal. undercoater		.....	.....	4.20	0.25
0.06 gal. enamel		.....	.....	8.00	.48
Painter	.72	.....	.....	6.00	4.32
Fourth Coat					
0.12 gal. enamel		.....	.....	8.00	.96
Painter	.77	.....	.....	6.00	4.62
Cost 100 lin. ft.	2.56		$.....		$17.98

For preparatory work and sanding between coats, add as given above.

For three coat work, omit cost of third coat.

For each additional coat, add same as fourth coat.

Cost of 100 Sq.Ft. (1 Sq.) Glazing and Wiping Over Enamel Trim

	Hours	Rate	Total	Rate	Total
0.09 gal. glazing liquid		$.....	$.....	$4.20	$0.38
Painter	1.60	.....	.....	6.00	9.60
Cost 100 sq. ft.	1.60		$.....		$9.98

FINISHING INTERIOR WOODWORK

The greatest variations in costs will be found in interior finishing, as this is principally a labor proposition. For instance, where two, three or four coats of paint, enamel or varnish are specified, some painters will apply the entire number of coats without sanding between coats, regardless of specifications. This saves time but produces an inferior job.

To produce a first class finish on interior woodwork, it is necessary to sand or rub down between coats to produce a smooth surface to receive the following coats. The finish coat will then be smooth and without rough spots, dust marks, etc. It is practically impossible to obtain this finish without sanding between coats.

The costs given on the following pages cover a customary, good residential job but if an exceptionally high grade of workmanship is required, increase labor costs accordingly.

Cost of Sanding 100 Sq. Ft. (1 Sq.) Interior Trim Before First Coat

	Hours	Rate	Total	Rate	Total
Painter	0.35	$.....	$.....	$6.00	$2.10

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of Sanding and Puttying 100 Sq. Ft. (1 Sq.) Interior Trim Between Coats

	Hours	Rate	Total	Rate	Total
Painter	0.50	$.....	$.....	$6.00	$3.00

Cost of 100 Sq. Ft. (1 Sq.) Light Sanding Interior Trim Between Coats

	Hours	Rate	Total	Rate	Total
Painter	0.30	$.....	$.....	$6.00	$1.80

Cost of Backpriming 100 Lin. Ft. of Interior Trim Up to 6 Inches Wide

	Hours	Rate	Total	Rate	Total
0.09 gal. primer		$.....	$.....	$4.20	$0.38
Painter	0.21	.....	.....	6.00	1.26
Cost 100 lin. ft.	0.21		$.....		$1.64

Cost of 100 Sq. Ft. (1 Sq.) 3-Coat Oil Paint Applied to Interior Doors, Windows, Cases, etc.

Priming Coat	Hours	Rate	Total	Rate	Total
0.17 gal. paint		$.....	$.....	$4.20	$ 0.71
Painter	0.70	.....	.....	6.00	4.20
Second Coat					
0.21 gal. paint		.....	.....	7.00	1.47
Painter	.85	.....	.....	6.00	5.10
Third Coat					
0.19 gal. paint		.....	.....	7.00	1.33
Painter	.85	.....	.....	6.00	5.10
Cost 100 sq. ft.	2.40		$.....		$17.91

For two-coat work, deduct cost of third coat.
For each additional coat of paint, add same as third coat.
Add for sanding and puttying as given on previous pages.

Cost of 100 Lin. Ft. 3-Coat Oil Paint Applied to Base, Chair Rail and Other Trim Less Than 6 Inches Wide

First Coat	Hours	Rate	Total	Rate	Total
0.09 gal. paint		$.....	$.....	$4.20	$ 0.38
Painter	0.40	.....	.....	6.00	2.40
Second Coat					
0.12 gal. paint		.....	.....	7.00	.84
Painter	.60	.....	.....	6.00	3.60
Third Coat					
0.12 gal. paint		.....	.....	7.00	.84
Painter	.70	.....	.....	6.00	4.20
Cost 100 lin. ft.	1.70		$.....		$12.26

For two coat work, deduct cost of third coat.
For each additional coat of paint, add same as third coat.
Add for sanding and puttying as given on previous pages.

Cost of 100 Sq. Ft. (1 Sq.) Spirit Stain Applied to Interior Woodwork

	Hours	Rate	Total	Rate	Total
0.25 gal. spirit stain		$.....	$.....	$4.75	$1.19
Painter	0.5	.....	.....	6.00	3.00
Cost 100 sq. ft.	0.5		$.....		$4.19

Cost of 100 Sq. Ft. (1 Sq.) Penetrating Oil Stain Applied to Interior Woodwork

	Hours	Rate	Total	Rate	Total
0.15 gal. oil stain		$.....	$.....	$4.75	$0.71
Painter	0.5	.....	.....	6.00	3.00
Cost 100 sq. ft.	0.5		$.....		$3.71

Cost of 100 Sq. Ft. (1 Sq.) Stain, Filler and Sealer, Wipe Off

	Hours	Rate	Total	Rate	Total
0.25 gal. paste filler		$.....	$.....	$4.20	$ 1.05
Painter	1.5	.....	.....	6.00	9.00
Cost 100 sq. ft.	1.5		$.....		$10.05

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of 100 Sq. Ft. (1 Sq.) Shellac Applied to Interior Woodwork

	Hours	Rate	Total	Rate	Total
0.15 gal. pure shellac.....		$.....	$.....	$4.50	$0.68
Painter	0.45	.....	.....	6.00	2.70
Cost 100 sq. ft.	0.45		$.....		$3.38

For sanding and puttying between coats, add as given on previous pages.

Cost of 100 Sq. Ft. (1 Sq.) One Coat Gloss Varnish Applied to Interior Woodwork

	Hours	Rate	Total	Rate	Total
0.23 gal. varnish		$.....	$.....	$7.00	$1.61
Painter	0.6	.....	.....	6.00	3.60
Cost 100 sq. ft.....	0.6		$.....		$5.21

For sanding and puttying between coats, add as given on previous pages.

Cost of 100 Sq. Ft. (1 Sq.) Flat Varnish Applied to Interior Woodwork

	Hours	Rate	Total	Rate	Total
0.16 gal. varnish		$.....	$.....	$7.00	$1.12
Painter	0.6	.....	.....	6.00	3.60
Cost 100 sq. ft.....	0.6		$.....		$4.72

For sanding and puttying between coats, add as given on previous pages.

Cost of 100 Sq. Ft. (1 Sq.) Wax and Polish Applied to Interior Woodwork

	Hours	Rate	Total	Rate	Total
0.18 gal. liquid wax.....		$.....	$.....	$4.20	$0.76
Painter	0.95	.....	.....	6.00	5.70
Cost 100 sq. ft.	0.95		$.....		$6.46

For sanding and puttying between coats, add as given on previous pages.

Paint costs vary according to quality used, color and local material prices. Add for surface preparation.

Cost of Rubbing 100 Sq. Ft. (1 Sq.) Varnish Finish to Dull Rubbed Finish

	Hours	Rate	Total	Rate	Total
0.33 lb. powd. pumice stone		$.....	$.....	$0.10	$ 0.03
0.13 gal. rubbing oil.....		.....	.....	.90	.12
1 lb. cotton waste.....		.....	.....	.35	.35
Painter	2.25	.....	.....	6.00	13.50
Cost 100 sq. ft.....	2.25		$.....		$14.00

Cost of 100 Sq. Ft. (1 Sq.) Interior Finish Consisting of 1-Coat Shellac and 1-Coat Varnish

First Coat	Hours	Rate	Total	Rate	Total
0.15 gal. pure shellac.....		$.....	$.....	$4.50	$0.68
Painter	0.45	.....	.....	6.00	2.70
Second Coat					
0.23 gal. varnish		.....	.....	7.00	1.61
Painter	.60	.....	.....	6.00	3.60
Cost 100 sq. ft.....	1.05		$.....		$8.59

For each additional coat of varnish, add same as second coat.

For sanding and puttying between coats, add as given on previous pages.

Cost of 100 Sq. Ft. (1 Sq.) Interior Finish Consisting of 1-Coat Oil Stain, 1-Coat Shellac and 2-Coats Varnish

First Coat	Hours	Rate	Total	Rate	Total
0.15 gal. oil stain.....		$.....	$.....	$4.75	$ 0.71
Painter	0.50	.....	.....	6.00	3.00
Second Coat					
0.15 gal. pure shellac.....		.....	.....	4.50	.68
Painter	0.45	.....	.....	6.00	2.70
Third Coat					
0.23 gal. varnish		.....	.....	7.00	1.61
Painter	0.60	.....	.....	6.00	3.60
Fourth Coat					
0.23 gal. varnish		.....	.....	7.00	1.61
Painter	0.60	.....	.....	6.00	3.60
Cost 100 sq. ft.....	2.15		$.....		$17.51

For each additional coat of varnish, add same as fourth coat.

For sanding and puttying between coats, add as given on previous pages.

If last coat of varnish is rubbed to a dull rubbed finish, add as given on previous pages.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Synthetic Resin Finish Applied to Standing Trim

First Coat	Hours	Rate	Total	Rate	Total
0.17 gal. resin finish.....		$.....	$.....	$4.75	$0.81
Painter	0.50	.....	.....	6.00	3.00
Second Coat					
0.16 gal. resin finish.....		.....	.....	4.75	.76
Painter	.47	.....	.....	6.00	2.82
Cost 100 sq. ft.....	0.97		$.....		$7.39

FINISHING HARDWOOD FLOORS

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Paint Applied to Wood Floors

First Coat	Hours	Rate	Total	Rate	Total
0.19 gal. paint		$.....	$.....	$7.00	$1.33
Painter	0.35	.....	.....	6.00	2.10
Second Coat					
0.23 gal. paint		.....	.....	7.00	1.61
Painter	.38	.....	.....	6.00	2.28
Cost 100 sq. ft.....	0.73		$.....		$7.32

Cost of 100 Sq. Ft. (1 Sq.) Paste Filler Applied to Hardwood Floors

	Hours	Rate	Total	Rate	Total
0.19 gal. paste filler		$.....	$.....	$4.25	$0.81
Painter	0.57	.....	.....	6.00	3.42
Cost 100 sq. ft.....	0.57		$.....		$4.23

Cost of 100 Sq. Ft. (1 Sq.) Varnish Applied to Hardwood Floors

	Hours	Rate	Total	Rate	Total
0.19 gal. varnish		$.....	$.....	$7.00	$1.33
Painter	0.33	.....	.....	6.00	1.98
Cost 100 sq. ft.....	0.33		$.....		$3.31

Cost of Machine Buffing 100 Sq. Ft. (1 Sq.) Hardwood Floors

	Hours	Rate	Total	Rate	Total
Machine	0.25	$.....	$.....	$0.40	$0.10
Painter	.25	.....	.....	6.00	1.50
Cost 100 sq. ft.....	0.25		$.....		$1.60

Cost of Waxing and Polishing 100 Sq. Ft. (1 Sq.) Hardwood Floors

	Hours	Rate	Total	Rate	Total
0.10 gal. wax		$.....	$.....	$4.25	$0.43
Painter	0.5			6.00	3.00
Cost 100 sq. ft.	0.5		$.....		$3.43

Cost of 100 Sq. Ft. (1 Sq.) Wax Applied to Asphalt Tile or Linoleum Floors

	Hours	Rate	Total	Rate	Total
0.10 gal. wax		$.....	$.....	$4.25	$0.43
Painter	0.5			6.00	3.00
Cost 100 sq. ft.	0.5		$.....		$3.43

Cost of 100 Sq. Ft. (1 Sq.) Hardwood Floor Finish Consisting of 1-Coat Paste Filler, 1-Coat Shellac and 1-Coat of Wax

First Coat	Hours	Rate	Total	Rate	Total
0.19 gal. paste filler		$.....	$.....	$4.25	$0.81
Painter	0.57			6.00	3.42
Second Coat					
0.15 gal. pure shellac				4.50	.68
Painter	.25			6.00	1.50
Third Coat					
0.10 gal. wax				4.25	.43
Painter	.50			6.00	3.00
Cost 100 sq. ft.	1.32		$.....		$9.84

Above costs based on using an electric polishing machine.

If floors are lightly sanded between coats, add same as buffing.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Penetrating Stain and Wax on Hardwood Floors

First Coat	Hours	Rate	Total	Rate	Total
0.19 gal. stainwax		$.....	$.....	$5.50	$1.05
Painter	0.25			6.00	1.50
Second Coat					
0.17 gal. stainwax				5.50	.94
Painter	.21			6.00	1.26
Cost 100 sq. ft.	0.46		$.....		$4.75

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Floor Seal on Hardwood Floors

First Coat	Hours	Rate	Total	Rate	Total
0.17 gal. floor seal.....		$.....	$.....	$5.75	$0.98
Painter	0.20	.....	.....	6.00	1.20
Second Coat					
0.09 gal. floor seal.....		.....	.....	5.75	.52
Painter	.17	.....	.....	6.00	1.02
Cost 100 sq. ft.....	0.37		$.....		$3.72

Where dark colored floor seal is used on oak floors, it will have to be wiped the same as where paste wood filler is used. Add extra labor for this work or refer to "Wood Floors" for this type of finish.

Cost of 100 Sq. Ft. (1 Sq.) Shellac Applied to Hardwood Floors

First Coat	Hours	Rate	Total	Rate	Total
0.19 gal. shellac		$.....	$.....	$4.50	$0.86
Painter	0.25	.....	.....	6.00	1.50
Second Coat					
0.15 gal shellac		.....	.....	4.50	.68
Painter	.21	.....	.....	6.00	1.26
Cost 100 sq. ft.....	0.46		$.....		$4.30

For each additional coat of shellac, add same as second coat.

Cost of 100 Sq. Ft. (1 Sq.) Hardwood Floor Finish Consisting of 1-Coat Stainfill, 1-Coat Shellac and 2-Coats Varnish

First Coat	Hours	Rate	Total	Rate	Total
0.21 gal. stain and fill..		$.....	$.....	$4.25	$ 0.89
Painter	0.38	.....	.....	6.00	2.28
Second Coat					
0.15 gal. pure shellac....		.....	.....	4.50	.68
Painter	.25	.....	.....	6.00	1.50
Third Coat					
0.19 gal. varnish		.....	.....	7.00	1.33
Painter	.33	.....	.....	6.00	1.98
Fourth Coat					
0.19 gal. varnish		.....	.....	7.00	1.33
Painter	.33	.....	.....	6.00	1.98
Cost 100 sq. ft.....	1.29		$.....		$11.97

For each additional coat of varnish, add same as fourth coat.

Cost of 100 Sq. Ft. (1 Sq.) Hardwood Floor Finish Consisting of 1-Coat Stain and Fill, 1-Coat Shellac, Wax and Polish

	Hours	Rate	Total	Rate	Total
First Coat					
0.21 gal. stain and fill....		$.....	$.....	$4.25	$0.89
Painter	0.38	.....	.....	6.00	2.28
Second Coat					
0.15 gal. pure shellac....		.....	.....	4.50	.68
Painter	.25	.....	.....	6.00	1.50
Third Coat					
0.10 gal. wax.....		.....	.....	4.25	.43
Painter	.50	.....	.....	6.00	3.00
Cost 100 sq. ft.....	1.13		$.....		$8.78

For each additional coat of wax, add same as third coat.

For lightly sanding between coats, add same as given for buffing.

Cost of Filling Old Wood Floors with Crevice Filler

	Hours	Rate	Total	Rate	Total
4 lbs. crevice filler.....		$.....	$.....	$0.30	$1.20
Painter	1	.....	.....	6.00	6.00
Cost 100 sq. ft.....	1		$.....		$7.20

Cost of Removing Old Varnish from 100 Sq. Ft. (1 Sq.) Old Wood Floors

	Hours	Rate	Total	Rate	Total
0.57 gal. varnish remover		$.....	$.....	$2.75	$ 1.57
Painter	2.2	.....	.....	6.00	13.20
Cost 100 sq. ft.....	2.2		$.....		$14.77

PAINTING AND DECORATING WALLS AND CEILINGS

Cost of Taping, Filling Joints and Sanding 100 Sq. Ft. (1 Sq.) Gypsum Wallboard

Based on approximately 1 lin. ft. of joint to 3 sq. ft. of sheetrock.

	Hours	Rate	Total	Rate	Total
33 lin. ft. tape-cement....		$.....	$.....	$0.02	$0.66
Painter	1	.....	.....	6.00	6.00
Cost 100 sq. ft.	1		$.....		$6.66
Cost per lin. ft.....			.....		.22

Cost of 100 Sq. Ft. (1 Sq.) Sizing Applied to New Smooth Finish Walls

	Hours	Rate	Total	Rate	Total
0.16 gal. size		$.....	$.....	$0.40	$0.06
Painter	0.27	.....	.....	6.00	1.62
Cost 100 sq. ft.	0.27		$.....		$1.68

Cost of 100 Sq. Ft. (1 Sq.) Prepared Wall Primer or Sealer Applied to Smooth Plaster or Dense Wallboard

	Hours	Rate	Total	Rate	Total
0.17 gal. sealer		$.....	$.....	$4.25	$0.72
Painter	0.45	.....	.....	6.00	2.70
Cost 100 sq. ft.	0.45		$.....		$3.42

If applied over porous insulating or fiber wallboard, figure 0.5 gal. of primer per 100 sq. ft.

Cost of 100 Sq. Ft. (1 Sq.) Prepared Wall Primer or Sealer to Sand Finish Plaster

	Hours	Rate	Total	Rate	Total
0.35 gal. sealer		$.....	$.....	$4.25	$ 1.49
Painter	0.80	.....	.....	6.00	4.80
Cost 100 sq. ft.	0.80		$.....		$6.29

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Sealer, 2-Coats Flat Wall Paint, Stippled, Applied to Smooth Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.17 gal. sealer		$.....	$.....	$4.25	$ 0.72
Painter	0.45	.....	.....	6.00	2.70
Second Coat					
0.19 gal. paint		.....	.....	5.25	1.00
Painter	.60	.....	.....	6.00	3.60
Third Coat					
0.17 gal. paint		.....	.....	5.25	.89
Painter	.55	.....	.....	6.00	3.30
Stippling					
Painter	.52	.....	.....	6.00	3.12
Cost 100 sq. ft.	2.12		$.....		$15.33

For 2-coat work, deduct cost of third coat.

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Sealer, 2-Coats Flat Wall Paint Applied to Sand Finish Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.35 gal. sealer		$.....	$.....	$4.25	$ 1.49
Painter	0.80	.....	.....	6.00	4.80
Second Coat					
0.24 gal. paint		.....	.....	5.25	1.26
Painter	.70	.....	.....	6.00	4.20
Third Coat					
0.22 gal. paint		.....	.....	5.25	1.16
Painter	.80	.....	.....	6.00	4.80
Cost 100 sq. ft.	2.30		$.....		$17.71

For 2-coat work, deduct cost of third coat.

Cost of 100 Sq. Ft. (1 Sq). 1-Coat Sealer, 2-Coats Gloss or Semi-Gloss Oil Paint Applied to Smooth Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.17 gal. sealer		$.....	$.....	$4.25	$ 0.72
Painter	0.45	.....	.....	6.00	2.70
Second Coat					
0.19 gal. paint		.....	.....	7.00	1.33
Painter	.57	.....	.....	6.00	3.42
Third Coat					
0.19 gal. paint		.....	.....	7.00	1.33
Painter	.70	.....	.....	6.00	4.20
Stippling					
Painter	1.10	.....	.....	6.00	6.60
Cost 100 sq. ft.	2.82		$.....		$20.30

For 2-coat work, deduct cost of third coat.

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Sealer, 2-Coats Gloss or Semi-Gloss Oil Paint Applied to Sand Finish Plaster

First Coat	Hours	Rate	Total	Rate	Total
0.35 gal. sealer		$.....	$.....	$4.25	$ 1.49
Painter	0.80	.....	.....	6.00	4.80
Second Coat					
0.26 gal. paint		.....	.....	7.00	1.82
Painter	.83	.....	.....	6.00	4.98
Third Coat					
0.24 gal. paint		.....	.....	7.00	1.68
Painter	.80	.....	.....	6.00	4.80
Cost 100 sq. ft.	2.43		$.....		$19.57

Cost of 100 Sq. Ft. (1 Sq.) Glazing and Mottling Over Smooth Plaster

	Hours	Rate	Total	Rate	Total
0.10 gal. glazing liquid...		$.....	$.....	$4.25	$0.43
Painter	1.15	.....	.....	6.00	6.90
Cost 100 sq. ft.....	1.15		$.....		$7.33

Cost of 100 Sq. Ft. (1 Sq.) Glazing and Mottling Over Sand Finish Plaster

	Hours	Rate	Total	Rate	Total
0.12 gal. glazing liquid...		$.....	$.....	$4.25	$ 0.51
Painter	1.60	.....	.....	6.00	9.60
Cost 100 sq. ft.....	1.60		$.....		$10.11

Cost of 100 Sq. Ft. (1 Sq.) Glazing and Highlighting Textured Plaster

	Hours	Rate	Total	Rate	Total
0.12 gal. glazing liquid....		$.....	$.....	$4.25	$0.51
Painter	1.15	.....	.....	6.00	6.90
Cost 100 sq. ft.....	1.15		$.....		$7.41

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Latex Base Paint Applied to Smooth Plaster

	Hours	Rate	Total	Rate	Total
0.31 gal. latex paint.....		$.....	$.....	$6.00	$1.86
Painter	0.67	.....	.....	6.00	4.02
Cost 100 sq. ft.	0.67		$.....		$5.88

Cost of 100 Sq. Ft. (1 Sq.) 1-Coat Latex Base Paint Applied to Sand Finish Plaster

	Hours	Rate	Total	Rate	Total
0.37 gal. latex paint.....		$.....	$.....	$6.00	$2.22
Painter	0.83	.....	.....	6.00	4.98
Cost 100 sq. ft.	0.83		$.....		$7.20

Cost of 100 Sq. Ft. (1 Sq.) Starch and Brush Stipple Over Painted Glazed Surfaces

	Hours	Rate	Total	Rate	Total
Painter	0.83	$.....	$.....	$6.00	$4.98

Colors in Oil

Colors ground fine in pure linseed oil. One-half pint cans.

Blacks	Price
Drop Black	$0.67
Lamp Black	.57
Blue	
Palco Blue	1.45
Prussian Blue	.91
Cobalt Blue	.91
Ultramarine Blue	.91
Brown	
Raw Turkey Umber	.59
Burnt Turkey Umber	.59
Raw Italian Sienna	.66
Burnt Italian Sienna	.66
Vandyke Brown	.59

Green	Price
Palco Green	$1.55
Chrome Green, L.	.78
Chrome Green, M.	.78
Chrome Green, D.	.78
Red	
Vermilion	1.10
Rose Lake	.91
Venetian Red	.58
Yellow	
Chrome Yellow, L.	1.29
Chrome Yellow, M.	1.29
Chrome Yellow, O.	1.29
Ochre	1.29

Shellac and Varnish

Kind of Material	Per Gal.
Shellac, White, 4-lb. Cut	$4.50-$ 5.50
Shellac, Orange, 4-lb. Cut	4.00- 5.00
Cabinet Finish Varnish	5.00- 7.00
Floor Varnish	6.00- 8.00
Flat Varnish	6.00- 8.00
Spar Varnish	8.00- 12.00
Varnish Remover, Liquid	3.00- 4.00
Varnish Remover, Paste	5.00- 6.00
Wallpaper Lacquer	5.00- 7.00
Wallpaper Lacquer Thinner	3.60- 4.80
Lacquer	6.50- 8.05
Lacquer Thinner	3.60- 4.80

Enamels and Enamel Undercoating

	Per Gal.
Enamel, Non-Yellowing White	$8.00-$10.00
Architectural Enamel Paint	6.00- 7.50
Enamel Undercoater	5.75- 7.45
Enamel, White	6.00- 7.65
Enamel, Quick Drying	6.00- 7.65
Enamel, Industrial	5.65- 7.10

Wall Size, Sealer, Paste, Etc.

		Price
Sizing, prepared	per gal.	$3.50-$4.50
Glue, Dry for Sizing	per lb.	.35- .50
Wall Primer and Sealer	per gal.	4.75- 5.85
Wallpaper Cleaner	per lb.	.25
Starch, gloss	per lb.	.15
Patching Plaster	per lb.	.15
Spackle	per lb.	.20
Glazing Liquid	per gal.	4.00- 5.00

Wood Fillers and Stains

	Price Per Gal.
Oil Stains	$4.25-$5.45
Acid Stains	4.25- 5.40
Penetrating Stainwax	5.00- 6.00
Stain, Varnish, all colors	5.00- 7.40
Stain, Fill and Seal	5.00- 6.50
Paste Wood Filler	4.00- 5.50
Floor Seal	5.70- 6.20

Floor Wax

Liquid Floor Wax	per gal.	$3.50-$5.50
Self-Polishing Wax	per gal.	4.00- 4.50
Paste Wax	per lb.	.60- .75

Creosote Shingle Stains

	Price per Gal.
Brown and Red	$3.80-$5.15
Greens and Grays	3.80- 5.15

Miscellaneous Paints

	Per Gal.
Ready Mixed House Paint (Best)	$6.00-$7.80
Ready Mixed House Paint	5.00- 6.00
House Paint—One Coat	5.75- 8.80
Porch and Floor Paint	6.10- 7.05
Flat Wall Paint	5.50- 6.25
Flat Wall Paint (Second Grade)	5.25- 5.85
One Coat Wall Paint (oil base)	5.25- 5.85
Latex Base Paint	5.00- 6.40
Metal Paint for structural steel, bridges, stacks, etc.	6.20- 8.00
Cement Floor Paint	5.00- 7.05
Cement Floor Paint (Rubber Base)	6.00- 7.50
Aluminum Paint	6.00- 6.80
Vinyl-Chloride Co-Polymer	7.00
Alkyd-Acrylic-Vinyl Chloride Co Polymer	3.95

Lettering on Glass or Wood

The cost of lettering will vary with the style and size of letters and whether painted or gold leaf.

The costs given on the following pages include only Roman or Gothic style letters, such as are ordinarily used for signs on doors, transoms, show windows, etc., and are based on all work being performed by experienced sign writers.

Plain Black Letters 2" to 4" High.—For plain black Gothic style letters or numerals, such as used on windows, transoms, office doors, etc., an experienced sign writer should average about 25 letters an hr. at the following cost per 100 letters:

	Hours	Rate	Total	Rate	Total
Sign painter	4	$.....	$.....	$6.00	$24.00
Paint, etc.		.....	.....	1.00	1.00
Cost 100 letters	4		$.....		$25.00
Cost per letter			.....		.25

Plain Black Letters 6" to 12" High.—An experienced sign writer should average 12 to 14 plain Gothic letters 6" to 12" high, an hr. at the following cost per 100 letters:

	Hours	Rate	Total	Rate	Total
Sign painter	7.7	$.....	$.....	$6.00	$46.20
Paint, etc.		.....	.....	2.00	2.00
Cost 100 letters	7.7		$.....		$48.20
Cost per letter			.....		.48

Gold Leaf Letters 2" to 4" High.—An experienced sign writer should complete about 5 plain Roman or Gothic letters in gold leaf an hr. (this class of work proceeds much slower than painted letters) at the following cost per 100 letters:

	Hours	Rate	Total	Rate	Total
Sign painter	20	$.....	$.....	$6.00	$120.00
Gold leaf, paint, etc.		.....	.....	8.00	8.00
Cost 100 letters	20		$.....		$128.00
Cost per letter			.....		1.28

Gold Leaf Letters 6" to 12" High.—An experienced sign writer should complete 2 to 3 plain Roman or Gothic letters 6" to 12" high, in gold leaf, an hr. at the following cost per 100 letters:

	Hours	Rate	Total	Rate	Total
Sign painter	40	$.....	$.....	$ 6.00	$240.00
Gold leaf, paint, etc.		.....	.....	28.00	28.00
Cost 100 letters	40		$.....		$268.00
Cost per letter			.....		2.68

WALLPAPER AND PAPER HANGING

Wallpaper is estimated by the roll containing 36 sq. ft. Most rolls are 18″ or 20½″ wide and contain 36 sq. ft. or 4 sq. yds. of paper. The double roll contains just twice as much as the single roll, viz.: 72 sq. ft. or 8 sq. yds. of paper.

Estimating the Quantity of Wallpaper Required for any Room.—When estimating the quantity of wallpaper required for any room, measure the entire distance around the room in lin. ft. and multiply by the height of the walls or the distance from the floor to the ceiling. The result will be the number of sq. ft. of surface in the four walls.

Make deductions in full for the area of all openings such as windows, doors, consoles, mantels, built-in bookcases, etc. The difference between the area of the four walls and the area of the openings will be the actual number of sq. ft. of surface to be papered.

When adding for waste in matching, cutting, fitting, etc., paper hangers use different methods and allow different percentages, contingent upon the height of the ceiling, the design of the paper, and the size of the pattern or figure, but an allowance of 15 to 20 per cent will prove sufficient in nearly all cases.

When estimating the quantity of paper required for walls, bear in mind it is not necessary to run the side wallpaper more than one or two inches above the border, when a border is used. The height of the wood base should also be deducted from the total height of the wall.

In rooms having drop ceilings, the depth of the drop should be deducted from the height of the wall, which will decrease the area of side wallpaper in the same amount as it increases the quantity of ceiling paper.

If a border is required, measure the distance around the room and the result will be the number of lin. ft. of border. Dividing by 3, gives the number of yards of border required.

When estimating the quantity of wallpaper required for ceilings, multiply the width of the room by the length, and the result will be the number of sq. ft. of ceiling to be papered.

In rooms having a drop ceiling, add the depth of the drop or the distance the ceiling paper extends down the side walls to the length and breadth of the room and multiply as described above.

After the areas of both side walls and ceiling have been computed in sq. ft. divide by 36, and the result will be the number of single rolls of paper required; or by dividing by 72 gives the number of double rolls of paper required.

Paste Required Hanging Wallpaper.—The quantity of paste required for hanging wallpaper will vary with the weight of the paper and the surface to which it is applied.

Where light or medium weight wallpaper is used, one gallon of paste should hang 12 single rolls of paper.

If heavy or rough texture paper is used, it will often be necessary to give it two or three applications of paste to obtain satisfactory results. On work of this kind one gallon of paste should hang 4 to 6 single rolls of paper.

There are prepared pastes on the market which require only the addition of cold water to make them ready for use.

One pound of prepared cold water dry paste should make 1½ to 2 gallons of ready to use paste.

Sufficiently prepared cold water dry paste to make 3 gallons of ready to use paste should cost as follows:

	Hours	Rate	Total	Rate	Total
2 lbs. dry paste		$.....	$.....	$0.20	$0.40
Labor	0.25	.....	.....	6.00	1.50
Total cost 3 gals. paste	0.25		$.....		$1.90
Cost per gal.....			.....		.63
Cost per roll lgt. wt. paper			.....		.05
Cost per roll hvy. wt. paper			.....		.13

Labor Hanging Wallpaper.—Different methods of hanging wallpaper are used in different sections of the country. In some localities a paper hanger and helper work together, one man trimming the paper and pasting while the other man hangs the paper, while in many cities the work is performed by one man, who cuts, trims, fits, pastes and hangs the paper.

The quantities and costs given on the following pages are based on the performance of one man but will prove a fair average for use in any locality.

Hanging Wallpaper on Walls and Ceilings, One Edge Work.—When hanging light or medium weight paper on ceilings and drops, a paper hanger should hang 28 to 32 single rolls of paper per 8-hr. day, at the following labor cost per roll:

	Hours	Rate	Total	Rate	Total
Paper hanger	0.27	$.....	$.....	$6.00	$1.62

Hanging Wallpaper on Walls, Butt Work.—Where light or medium weight paper is used for bed rooms, halls, etc., and where a good grade of workmanship is required with all paper trimmed on both edges and hung with butt joints, a paper hanger

should trim, fit and hang 20 to 24 single rolls of paper per 8-hr. day, at the following labor cost per roll:

	Hours	Rate	Total	Rate	Total
Paper hanger	0.36	$.....	$.....	$6.00	$2.16

Another thing that will slow up the work is where new paper is applied over old rough textured wallpaper, such as oatmeal designs, etc.

Hanging Wallpaper, First Grade Workmanship.—Where a good grade of medium or heavy weight wallpaper is used, with all paper hung with butt joints, a paper hanger should trim, fit and hang 16 to 20 single rolls of paper per 8-hr. day, at the following labor cost per roll:

	Hours	Rate	Total	Rate	Total
Paper hanger	0.44	$.....	$.....	$6.00	$2.64

Labor Hanging Scenic Paper.—Where scenic paper or paper having mural designs are used over the wall or up stairways, a paper hanger will hang only 8 to 10 single rolls per 8-hr. day, at the following labor cost per roll:

	Hours	Rate	Total	Rate	Total
Paper hanger	0.9	$.....	$.....	$6.00	$5.40

Placing Wallpaper Borders.—Wallpaper borders are usually estimated by the lin. ft. or yd. and as the width varies from 3″ to 18″ there is never over one width required.

The average size room requires 50 to 60 lin. ft. or 17 to 20 yds. of border.

A paper hanger should place border in a room of this size in 30 to 40 minutes, which is at the rate of 100 to 125 lin. ft. an hr.

The labor cost per 100 lin. ft. (33⅓ yds.) should run as follows:

	Hours	Rate	Total	Rate	Total
Paper hanger	0.9	$.....	$.....	$6.00	$5.40
Cost per 100 lin. ft. ...	0.9		$.....		$5.40
Cost per lin. ft.			.....		.05
Cost per yd.			.....		.15

Hanging Coated Fabrics.—Where coated fabrics, such as Walltex, Sanitas, etc., are used, a paper hanger should hang

16 to 20 single rolls per 8-hr. day, at the following labor cost per roll:

	Hours	Rate	Total	Rate	Total
Paper hanger	0.44	$.....	$.....	$6.00	$2.64

Canvassing Plastered Walls.—When applying canvas to plastered walls, an average mechanic should apply 50 to 60 sq. ft. an hour.

Cost of 100 Sq. Ft. Canvassed Walls

	Hours	Rate	Total	Rate	Total
12 sq. yds. canvas		$.....	$.....	$0.50	$ 6.00
4 lbs. dry paste		.....	.....	.20	.80
Paper hanger	1.82	.....	.....	6.00	10.92
Cost 100 sq. ft.	1.82		$.....		$17.72
Cost per sq. ft.			.....		.18

Flexwood.—Flexwood is a genuine wood veneer cut to 1/85 of an inch, glued under heat and hydraulic pressure to cotton sheeting with a waterproof adhesive. A patented flexing operation breaks the cellular unity of the wood to produce a limp, pliable sheet which may be applied by hand to any smooth surface, flat or curved. Waterproof Flexwood cement, which makes a permanent bond, is used to apply Flexwood. Standard sizes of stock material are 18-in. and 24-in. widths and 8-ft. and 10-ft. lengths.

The mechanics of installing Flexwood are as follows: the background is sized with Flexwood cement. Another coating of cement is brushed on the Flexwood which is then hung in the manner of any sheet wall covering. A stiff, broad knife, used with considerable pressure, smooths out the Flexwood, removes air spaces and furnishes the necessary contact.

Some of the wood available in Flexwood are mahogany, walnut, oak, prima vera, knotty pine, orientalwood, satinwood, zebrawood, rosewood, English oak, maple, lacewood, etc. The cost of the material varies from $0.66 to $2.74 per sq. ft. depending upon the kind of wood. The majority of woods run from $0.75 to $1.00. Adhesive runs $8.25 per gallon. Dado stock with heights not exceeding 48" are available at 55¢ per sq. ft. for mahogany, 67¢ for birch, and 71¢ for oak and walnut.

It requires a skilled and thoroughly competent paper hanger to apply this material and the labor costs vary considerably with the design to be obtained.

Considerable time is usually required to lay out any room to obtain the desired effect, spacing of strips, etc. This is especially

true where certain designs must be obtained on columns, walls and pilasters and where narrow strips of contrasting woods are used to obtain inlay effects.

On plain walls without inlays, a paper hanger experienced in this class of work should apply 95 to 105 sq. ft. of Flexwood per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Paper hanger	8	$.....	$.....	$6.00	$48.00
Cost per sq. ft.					.48

On pilasters, columns and walls inlaid with narrow strips of contrasting woods, the work is considerably slower, due to the additional cutting and fitting required. On work of this kind, a paper hanger, experienced in this class of work should apply 50 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Paper hanger	16	$.....	$.....	$6.00	$96.00
Cost per sq. ft.					.96

Additional time for paper hanger or foreman will be required laying out the work into patterns, marking off strips, etc. This will vary with the size of the job.

Add for overhead expense and profit.

After the Flexwood is applied, the joints should be sanded lightly to remove any imperfections in the joints.

Finishing Flexwood.—Flexwood will take any wood finish but where the natural color of the wood is desired, the Flexwood is given one coat of lacquer sealer, sanded lightly between coats and then given one coat of lacquer for a finish coat.

One gallon of lacquer sealer will cover about 300 sq. ft. of surface, one coat.

After the sealer has been applied, one gallon of lacquer should cover 450 to 500 sq. ft.

An experienced painter should apply lacquer sealer, sand lightly between coats and apply one coat of lacquer to 90 to 110 sq. ft. of surface an hr. at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Painter	1	$.....	$.....	$6.00	$6.00
Cost per sq. ft.					.06

Add for overhead expense and profit.

Vicrtex.—Vicrtex is a dimensionally stable vinyl wall covering composed of a woven cotton fabric to which a compound of vinyl resin, pigment, and plasticizer is electronically fused to one side. Vicrtex comes 54" wide in 30 yard rolls in three weights: heavy (36 oz. per lineal yard); medium (24-33 oz. per lineal yard); and light (22-24 oz. per lineal yard). It is available in over 1000 color-pattern combinations.

Some of the patterns available simulate linens, silks, moires, grasses, tweeds, Honduras mahogany, travertine, damasks and burlaps. Costs range from 40¢ to 65¢ per square foot installed.

Vicrtex is hung using regular wallpaper hanging procedures for hanging fabric baked wallcoverings. A broad knife is used to smooth out any wrinkles, air pockets and insures a good contact. Wash off any excess paste that remains on the surface of the material: No further finishing is necessary.

Vicrwall—an economy grade lightweight vinyl wallcovering, designed to be used in light abuse areas. It is made in two qualities: VW-73 (17.3 oz. per lineal yard, 54" wide, pre-trimmed, 45 lineal yards per roll); and VW-152 (20 oz. per lineal yard, 54" wide, 30 lineal yards per roll). Both qualities have woven cotton fabric backs. Costs will range from 30¢ to 40¢ per square foot installed.

Vicrtex T—is a line of wallcoverings composed of Vicrtex and Vicrwall qualities having a ½ mil film of DuPont Tedlar laminated to the surface. Tedlar is a non-porous material that is impervious to most known chemicals and dye stuffs. Tedlar on vinyl creates a surface resistant to ballpoint pen ink, lipstick, magic markers, shoe polish, and most staining agents. In addition to this, most chemicals, caustics or acids are harmless to this surface. If the surface is marked with these agents, they are removable with either detergent and water, or a proper solvent. Tedlar is best used in areas where such abuse or treatment is evident. The use of vinyl surfaced with Tedlar adds a premium of approximately 8½¢ per square foot to the cost of the material.

A competent paper hanger can apply approximately 400 sq. ft. per 8 hr. day at the following costs per 100 sq. ft.

	Hours	Rate	Total	Rate	Total
Paper hanger	2	$.....	$.....	$6.00	$12.00
Cost per sq. ft.					.12

Add for overhead expense and profit.

One gallon of Carpenter's F-1460W paste covers approximately 10 lineal yards of 54" width material.

Paste — $3.25 gallon (in 4 gal. case)
150 ft. = .024¢ per sq. ft.

To the above add overhead expenses and profit.

If excessive cutting and fitting is required the above figures should be increased to allow for the above conditions.

Painting Pipe

The cost of painting pipe will vary considerably, depending upon accessibility of work, layout of piping, scaffolding required, type of paint, whether one color or more, and in the case of old

work, the amount of surface preparation required and whether or not pipes are in service.

When estimating painting pipe, quantities are expressed in square feet of surface. When pipe quantities are measured from drawings, determine whether or not pipes are covered and thickness of same, as this will greatly affect the diameter and consequently the surface area, especially in the smaller sizes. Most estimators convert lineal feet of pipe to square feet of surface according to the following table:

O.D. Pipe or Covering	Sq. Ft. Area per Lin. Ft.	O.D. Pipe or Covering	Sq. Ft. Area per Lin. Ft.
3" and under	1	16" to 19"	5
4" to 7"	2	20" to 22"	6
8" to 11"	3	23" to 26"	7
12" to 15"	4	27" to 30"	8

Various types of paint materials are specified for pipes depending upon their function, exposure, whether bare or covered, etc. Average material coverages and approximate prices for a few of these materials are as follows:

Description	Sq. Ft. per Gal	Price per Gal.
Bare Pipe		
Black asphalt paint	One Coat 130-150	$1.50-$ 2.00
Aluminum paint	Each Coat 550-600	6.00- 6.80
Radiator enamel	Each Coat 550-600	7.00- 9.50
Covered Pipe		
Sizing	One Coat 350-400	.40- .50
Paint (oil base)	Each Coat 450-500	7.00- 9.50
Industrial enamel	1st Coat 450-500	7.00- 10.50
Industrial enamel	2nd Coat 550-600	7.00- 10.50

Labor Painting Pipe.—Labor costs for painting pipes are extremely variable due to the many conditions which may be encountered.

For simple work, consisting of horizontal runs and risers within stepladder reach, all painted one color, a painter should paint 1,100 to 1,200 sq. ft. of pipe, one coat, per 8-hr. day.

For boiler room or steam power plant piping of average difficulty, where some high ladder work is required, a painter should paint 750 to 850 sq. ft. of pipe, one coat, per 8-hr day.

For difficult industrial process piping or in very congested steam power plants, where most of the work requires high scaffolding, a painter will paint only 350 to 450 sq. ft. of pipe, one coat, per 8-hr. day.

If pipes are painted different colors, for identification, reduce the above production 10 to 15 percent.

If pipes are coded by color banding at 10 to 15 foot intervals, consider this work as another coat for labor, but practically no material will be required.

PAINTING STRUCTURAL STEEL

The cost of painting structural steel after erection will depend upon a number of factors, i. e., the weight of the steel, whether light or heavy sections; access to work and method of painting, whether brush painting by hand or using a spray.

Lightweight members cost more to paint than heavy members, and the less climbing required, the more paint a man will apply, either by brush or when using a spray.

Structural steel may be estimated, either by the ton of steel or by the number of square feet of surface to be painted.

The ton method is much easier to compute but the square feet of surface method is much more accurate.

The following tables giving the approximate number of square feet of area on various size beams, angles and channels will assist the estimator in computing accurate quantities where the square foot method is used.

Number of Sq. Ft. Area Per Lin. Ft. of Structural "I" Beams of Various Sizes

Depth Beam Inches	Weight per Lin. Ft. Lbs.	Sq. Ft. Area per Lin. Ft.	Depth of Beam Inches	Weight per Lin. Ft. Lbs.	Sq. Ft. Area per Lin. Ft.
3	5- 8	1.25	10	25- 40	3.40
4	7-10	1.40	12	31- 55	3.70
5	10-15	1.90	15	42- 75	4.50
6	12-17	2.00	18	54- 70	5.00
7	15-20	2.60	20	65-100	5.40
8	18-25	2.70	24	80-120	6.40
9	21-35	2.90	27	90-135	7.50

Number of Sq. Ft. Area Per Lin. Ft. of Structural Channels of Various Sizes

Depth of Channel Inches	Weight per Lin. Ft. Lbs.	Sq. Ft. Area per Lin. Ft.	Depth of Channel Inches	Weight per Lin. Ft. Lbs.	Sq. Ft. Area per Lin. Ft.
3	4- 6	1.00	9	14-25	2.35
4	5- 7	1.20	10	15-35	2.70
5	7-11	1.50	12	21-40	3.00
6	8-16	1.70	15	32-50	3.70
7	10-20	2.00	18	34-55	4.40
8	11-21	2.20	20	42-58	5.00

Number of Sq. Ft. Area Per Lin. Ft. of Structural Angles of Various Sizes

Size of Angle Inches	Weight per Lin. Ft. Lbs.	Sq. Ft. Area per Lin. Ft.	Size of Angle Inches	Weight per Lin. Ft. Lbs.	Sq. Ft. Area per Lin. Ft.
2x2	2- 5	0.70	4x3	4-17	1.20
3x3	2-11	1.00	5x3	6-19	1.40
4x4	5-20	1.35	6x4	10-30	1.70
5x5	8-31	1.70	7x4	13-34	1.90
6x6	13-40	2.00	8x4	17-37	2.00
8x8	26-57	2.70	8x6	20-50	2.40

Painting Lightweight Structural Steel After Erection.—When painting lightweight structural steel after erection, by hand, using a brush, a painter should paint 600 to 650 sq. ft. per 8-hr. day on the first coat; and 800 to 900 sq. ft. per 8-hr. day on the second and third coats.

On a tonnage basis, this would be at the rate of 2 to 3 tons per 8-hr day on the first coat and 3 to 4 tons per 8-hr. day on the second and third coats.

When using a spray gun, a painter should paint 750 to 850 sq. ft. per 8-hr. day on the first coat and 1,000 to 1,100 sq. ft. on the second and third coats.

Painting Medium to Heavyweight Structural Steel After Erection.—When painting medium to heavyweight structural steel after erection, by hand, using a brush, a painter should paint 750 to 850 sq. ft. on the first coat and 900 to 1,000 sq. ft. per 8-hr. day on the second and third coats.

On a tonnage basis, this would be at the rate of 5½ to 6½ tons per 8-hr. day on the first coat and 6½ to 7½ tons per 8-hr. day on the second and third coats.

Using a spray gun, a painter should paint 850 to 950 sq. ft. per 8-hr. day on the first coat and 1,100 to 1,200 sq. ft. per 8-hr. day on the second and third coats.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Lead and Oil Paint Applied to Lightweight Structural Steel

First Coat	Hours	Rate	Total	Rate	Total
0.17 gal. metal primer		$.....	$.....	$9.00	$ 1.53
Painter	1.3	.....	.....	6.00	7.80
Second Coat					
0.11 gal. metal paint		.....	.....	7.00	.77
Painter	1.0	.....	.....	6.00	6.00
Cost 100 sq. ft.	2.3		$.....		$16.10

For third coat, add same as second coat.

SPRAY PAINTING

First Coat	Hours	Rate	Total	Rate	Total
0.22 gal. metal primer....		$.....	$.....	$9.00	$ 1.98
Painter	1.0	.....	.....	6.00	6.00
Second Coat					
0.15 gal. metal paint.....		.....	.....	7.00	1.05
Painter	0.8	.....	.....	6.00	4.80
Cost 100 sq. ft.....	1.8		$,....		$13.83

For third coat, add same as second coat.

Add for air compressor and engineer, depending upon number of spray guns operated.

Cost of 100 Sq. Ft. (1 Sq.) 2-Coat Lead and Oil Paint Applied to Medium to Heavyweight Structural Steel

First Coat	Hours	Rate	Total	Rate	Total
0.17 gal. metal primer....		$.....	$.....	$9.00	$ 1.53
Painter	1.0	.....	.....	6.00	6.00
Second Coat					
0.11 gal. metal paint.....		.....	.....	7.00	.77
Painter	0.9	.....	.....	6.00	5.40
Cost 100 sq. ft.	1.9		$.....		$13.70

For third coat, add same as second coat.

SPRAY PAINTING

First Coat	Hours	Rate	Total	Rate	Total
0.22 gal. metal primer....		$.....	$.....	$9.00	$ 1.98
Painter	0.9	.....	.....	6.00	5.40
Second Coat					
0.15 gal. metal paint.....		.....	.....	7.00	1.05
Painter	0.7	.....	.....	6.00	4.20
Cost 100 sq. ft.	1.6		$.....		$12.63

For third coat, add same as second coat.

Add for air compressor and engineer, depending upon number of spray guns operated.

PREPARING STEEL SURFACES

Proper protection of steel depends upon proper adhesion of the protective paint. Thus, when rust, oils, grease, scale and other dirt are not completely removed, the paint coat or coats will fail no matter how skillfully they are applied.

The Steel Structures Painting Council (SSPC) publishes detailed specifications for cleaning methods.

The simplest, of course, is hand cleaning using scrapers, sanders, wire brushes and chipping tools. These remove only loose rust and scale and effectiveness depends largely on the zeal of the

worker. Cost will run from 4¢ to 8¢ per sq. ft. with a durability of 2 to 5 years.

Brush blasting substitutes propelled abrasive materials for hand labor and at the same cost, but still removes only the loose contaminent.

Power tool cleaning, using power operated sanders and brushes is slightly more expensive, slightly more effective, with a cost of 6¢ to 10¢ per sq. ft. and a durability of 3 to 5 years.

With all the above methods, it is essential to use a primer with a good "wetting" power.

For a superior job, one of the blasting methods is suggested: commercial, near white, or white. The last specifies the metal be blasted down to a uniform "white" surface. It will cost from 25¢ to 50¢ per sq. ft. but should provide a base good for 7 to 8 years. Near white specifies that at least 95% of the metal will meet the "white" surface test. Its price range is 15¢ to 20¢ per sq. ft. and its durability almost equal to white blast.

Commercial blast is difficult to specify, but the results should leave at least two-thirds of the metal in the "white" stage. Costs range from 10¢ to 15¢ per sq. ft. with durability of from 6 to 7 years.

In figuring all these methods, cleaning up and protection for adjacent surfaces can add materially to the cost.

CHAPTER XX

GLASS AND GLAZING; METAL STORE FRONTS

While glass is not one of the largest items entering into the cost of a building, it is a branch of work that requires a vast amount of detail to prepare an accurate estimate, and for that reason should be figured with the utmost care.

Estimating material to be purchased from a glass dealer becomes more complicated each year.

Instead of so many lights of glass at a certain price per light, it now includes clear glass, both sheet (window) and plate, of many types, colors and fabrications, as well as obscure glass of many patterns, thicknesses and uses.

From the same dealer you will purchase metal store front material and metal for ventilators and door enclosures—also the glass blocks required, which will be installed by the mason.

Sheet (window) glass and shock mirrors (silvered window glass) are figured from lists prepared by the glass manufacturers, giving list prices for each stock size in both single and double strength, using discounts quoted by your dealer.

Window glass is made of double strength ($\frac{1}{8}$" thick) or single strength thicknesses. Heavy sheet glass (crystal) is made in $\frac{3}{16}$" or $\frac{7}{32}$" thicknesses.

Plate glass and mirrors (not exceeding $\frac{1}{4}$" thick) are sold by sq. ft.

Plate glass heavier than $\frac{1}{4}$" is figured on a square foot basis, using even inch dimensions, when making extensions of footage.

Of the obscure or fancy patterns, most have the footage figured on the actual inch basis (using the next full inch if there are fractions). However, some (especially the higher priced patterns) are figured on an even inch basis.

Estimating the Quantity of Glass Required.—When measuring and listing the glass quantities for any job, always list each kind of glass separately, such as single strength, "A" or "B", double strength "A" or "B", plate, mirrors, ribbed glass, etc., as they are all figured from different lists and each takes a different discount or square foot price.

Labor Glazing Window Glass.—In the larger cities the glass is sent to the job and the glazing is done in the building after the sash are fitted and primed. In smaller cities and towns where stock sash are used, the sash are usually glazed in the mill before being sent to the job. It costs much less to glaze in the mill than on the job, so this item should be taken into consideration when pricing the work.

The labor cost of glazing will vary with the size and kind of glass, and whether set in putty or glazing compound, a Thiokol or Silicone sealant, or with wood or metal stops. Putty is now seldom recommended for glazing except on a very small light under 50 unit inches (length plus width).

The estimator should have in his reference library the "Glazing Manual of the Flat Glass Jobbers Association" which reviews in detail recommended glazing procedures.

Glazing Contractor's Overhead Expense and Profit.—To the following labor costs on glazing, it will be necessary to add cost of putty or glazing compound, glazing contractor's overhead expense, social security and unemployment compensation taxes, compensation insurance, and profit.

Labor Setting Window or Plate Glass in Wood Sash, Using Putty or Glazing Compound

Approximate Size of Glass	Number Lights Set 8-Hr. Day	Glazier Hours per 100 Lights
12"x14"	65	12.5
20"x28"	40	20.0
30"x40"	30	26.7
40"x48"	20	40.0

Labor Setting Window or Plate Glass Using Wood Stops

Approximate Size of Glass	Number Lights Set 8-Hr. Day	Glazier Hours per 100 Lights
12"x14"	40	20.0
20"x28"	20	40.0
30"x40"	15	53.3
40"x48"	12	66.7

Putty Required Setting Glass in Wood Sash.—Window glass set in 1⅜" wood sash requires 1-lb. of putty for each 8 to 8½ lin. ft. of glass or sash rabbet; when set in 1¾" sash it requires 1-lb. of putty to each 7¼ to 7½ lin. ft. of glass or sash rabbet.

The following table gives the quantity of putty required for glazing various size glass:

Sash Thick	Size of Glass Inches 12"x14"	14"x20"	20"x28"	30"x36"	40"x48"
1⅜"	½ lb.	⅝-lb.	1 lb.	1⅜-lb.	1¾-lb.
1¾"	⅝-lb.	¾-lb.	1⅛-lb.	1½-lb.	2 -lbs.

A good grade of wood sash putty will cost about 12 cts. per lb.

Steel sash putty consisting of white lead and litharge will cost about 25 percent more than wood sash putty.

Elastic glazing compounds will cost from 20 cts. to 25 cts. per lb. depending on the brand. They also require a little more putty by weight per lineal foot of rabbet as they weigh more per gallon than regular putty.

Labor Setting Glass in Metal Doors.—When glazing metal doors and enclosures, the stops are usually steel and are fastened to the sash with small screws, and a glazier must remove all the screws from the stops, place the glass, and then replace the screws for each small light of glass. On work of this kind a glazier should set about 15 lights per 8-hr. day, at the following labor cost per 100 lights:

	Hours	Rate	Total	Rate	Total
Glazier	53.3	$.....	$.....	$6.10	$325.13
Cost per light					3.25

Labor Setting Plate Glass in Store Fronts.—The labor cost of handling and setting plate glass in store fronts will vary with the size of the glass, the length of the haul, etc.

The average size plate glass used in modern store fronts requires 5 to 6 men to handle and set each light of glass. No matter how many lights of glass there are in the job, nor how small some of the lights, it will be necessary to allow time for all the men, also a time allowance for glaziers going to the job and returning to the warehouse after completion, and time for truck and driver hauling glass from the warehouse to the job and return.

Unless the job is a considerable distance from the warehouse, an allowance of 1 hour time for each man going to the job and returning to the warehouse should prove sufficient.

It is customary for the truck and driver to remain on the job until the glass is set and return to the warehouse with the men, so that truck time should be figured on this basis.

Labor Setting Plate Glass in Store Front Using Metal Store Front Construction.—Refer to illustration of Fig. 1—Metal Store Front Construction under "Metal Store Fronts."

A store front 28 to 30 ft. wide, using metal construction as illustrated, with plate glass 9'-0" high. It will require about 7 hrs. time for 7 men to set the glass complete. In addition, it will be necessary to add 1-hr. traveling time for the glaziers, truck and driver.

The labor setting glass should cost as follows:

	Hours	Rate	Total	Rate	Total
Truck and driver.....	7	$.....	$.....	$5.10	$ 35.70
Traveling time	8	.....	.....	5.10	40.80
Glaziers	49	.....	.....	6.10	298.90
Total labor cost.....	64		$.....		$375.40

Cost to install 1 glass entrance door and 2 side lights and 1 glass vestibule door and 1 side light, including 2 floor hinges and hold-open devices will cost about $300.00 plus overhead expense and profit added to all labor costs.

Labor Setting Plate Glass in Store Front Similar to No. 2.—Refer to illustration under "Metal Store Fronts."

Setting plate glass for a store front 32 to 36 ft. wide, having plate glass 11'-0" high, including 2 small wall cases, will require about 7 hrs. time for 6 men.

In addition, it will be necessary to add 7 hrs. for the truck and driver and 1-hr. for the glaziers, truck and driver for traveling time.

The labor setting the glass should cost as follows:

	Hours	Rate	Total	Rate	Total
Truck and driver	7	$.....	$.....	$5.10	$ 35.70
Traveling time	7	.....	.....	5.10	35.70
Glaziers	42	.....	.....	6.10	256.20
Total labor cost	56		$.....		$327.60

Cost to install 1 pair of glass doors with floor hinges and free-standing door frame will be about $250.00, plus overhead expense and profit on all labor charges.

Labor Setting Plate Glass in Store Front Similar to No. 3.—Refer to illustration under "Metal Store Fronts."

When setting plate glass in store fronts similar to No. 3, with a store front 26 to 30 ft. wide and having glass 9'-6" high, it will require about 7 hrs. time for 6 men, plus traveling time, truck and driver, as follows:

	Hours	Rate	Total	Rate	Total
Truck and driver	7	$.....	$.....	$5.10	$ 35.70
Traveling time	7	.....	.....	5.10	35.70
Glaziers	42	.....	.....	6.10	256.20
Total labor cost	56		$.....		$327.60

Cost to install one glass door, with floor hinge and 2 glass side lights, about $165.00, plus overhead expense and profit added to all labor costs.

Labor Setting Plate Glass in Store Front No. 4 Using Metal Construction.—Refer to illustration under "Metal Store Fronts."

Labor setting plate glass only in store front No. 4, which is 20 to 24 ft. wide and has plate glass 9 ft. high.

It will require 7 hrs. time for 6 men to set the glass complete, including the bent plate.

In addition, it will be necessary to add 7 hrs. for truck and driver and 1 hr. traveling time for glaziers, truck and driver.

The labor setting the plate glass should cost as follows:

	Hours	Rate	Total	Rate	Total
Truck and driver	7	$.....	$.....	$5.10	$ 35.70
Traveling time	7	.....	.....	5.10	35.70
Glaziers	42	.....	.....	6.10	256.20
Total labor cost	56		$.....		$327.60

The above costs are based on the use of mitered corners, which are held together with small metal clamps and have an elastic compound put in with a putty knife to fill the joint. If metal corner bars are used instead of mitered corners, the cost, including the extra corner bars required, will be about the same.

Make no deductions for truck and driver and traveling time for glaziers.

Labor Setting Plate Glass Only in Store Front No. 5 Using Metal Construction.—Refer to Illustration under "Metal Store Fronts." This front is from 40 to 44 ft. wide and has plate glass 8 ft. high, tilted out at the top to avoid reflections from across the street.

It will require 7 hrs. time for 6 men to set this glass complete. In addition, it will be necessary to add 7 hrs. for the truck and driver and 1 hr. traveling time for glaziers, truck and driver.

The labor setting the glass only should cost as follows:

	Hours	Rate	Total	Rate	Total
Truck and driver.....	7	$.....	$.....	$5.10	$ 35.70
Traveling time	7	.....	.....	5.10	35.70
Glaziers	42	.....	.....	6.10	256.20
Total labor cost	56		$.....		$327.60

The above costs are based on the use of mitered corners, which are held together with small metal clips and have an elastic compound put in with a putty knife to fill the joint. If metal corner bars are used instead of mitered corners, the cost, including the extra corner bars required, will be about the same.

Make no deduction for truck and driver and traveling time for glaziers.

Number of Men Required for Various Sizes of Plate Glass in Store Fronts

From 120 united inches up to 140 united inches ...Two (2) men
From 140 united inches up to 160 united inches ...Three (3) men
From 160 united inches up to 180 united inches ...Four (4) men
Not over 210 united inches .....Five (5) men
Not over 240 united inches .....Six (6) men
Not over 270 united inches .....Seven (7) men
Not over 290 united inches .....Eight (8) men
Not over 310 united inches .....Nine (9) men
On all sizes larger than the above .....Ten (10) men to fifteen (15) men

It is further required that (1) when glass is set six feet or more over street level, (2) when weather conditions require it, or (3) when insulated glass (such as Thermopane or Twindow) is installed, additional men shall be used on the following basis:

First size enumerated in the schedule .....1 additional man
Next two sizes enumerated in the schedule .....2 additional men
Next three sizes enumerated in the schedule ...3 additional men

Labor Glazing Steel Sash.—The labor cost of glazing steel sash will vary with the size of the glass, amount of putty required per light, and the class of work; i. e., whether sidewall sash, monitor sash, etc., also whether it is necessary to hoist the glass and erect special scaffolding to set it.

The time of year in which the work is performed will also influence the labor costs, as a glazier can set more glass in warm weather than during the winter months. The labor costs given below are based on summer glazing. For winter work add up to 25% to costs given.

Putty Required for Glazing Steel Sash.—Putty used for glazing steel sash is a special mixture, part of which is red or white-lead. One lb. should be sufficient to glaze 5 to 5½ lin. ft. of sash rabbet. For instance, a 16"x20" light would contain 72" or 6'-0" to be puttied.

Elastic glazing compound is displacing the regular steel sash putty to a great extent for use in steel sash and must be used in aluminum sash.

Sufficient putty to glaze 100 lin. ft. of steel sash should cost as follows:

	Pounds	Rate	Total	Rate	Total
Putty	20	$.....	$.....	$0.12	$2.40
Cost per lin. ft.			.....		.03
	Pounds	Rate	Total	Rate	Total
Elastic compound	20	$.....	$.....	$0.20	$4.00
Cost per lin. ft.			.....		.04

See previous page of this chapter regarding elastic caulking compound.

Labor Glazing Steel Sash.—On jobs where there are no unusual window heights or other abnormal conditions, a glazier should set the following number of lights of glass in the various types of steel sash per 8-hr. day.

In clerestory, monitor or outside setting (from scaffold or swing stage), it will require one man on the ground for each two men on the scaffold to keep them supplied with glass, putty, etc. This adds approximately 50 percent to the costs as given below.

Add up to 25 percent to the following costs for winter work.

Pivoted Steel or Commercial Projected Steel Windows*

Glass Size Inches	Number Lights per 8-Hr. Day	Glazier Hrs. per 100 Lts.	Lbs. Putty per Light
22"x16"	50	26.7	1.25
32"x16"	40	26.7	1.50
32"x22"	30	32.0	1.67

Housing and Residence Steel Casements**

9"x12"	60	20.0	0.75
16"x12"	60	23.0	1.0
18"x12"	60	23.0	1.0

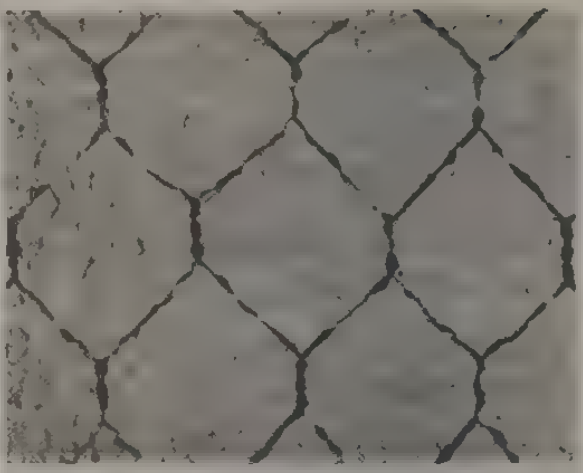
Architectural Projected Steel Windows**

18"x16"	30	23.0	1.25
20"x16"	30	23.0	1.25
38"x16"	25	40.0	1.75
40"x16"	25	50.0	2.00
46"x16"	25	50.0	2.00
48"x16"	25	50.0	2.25

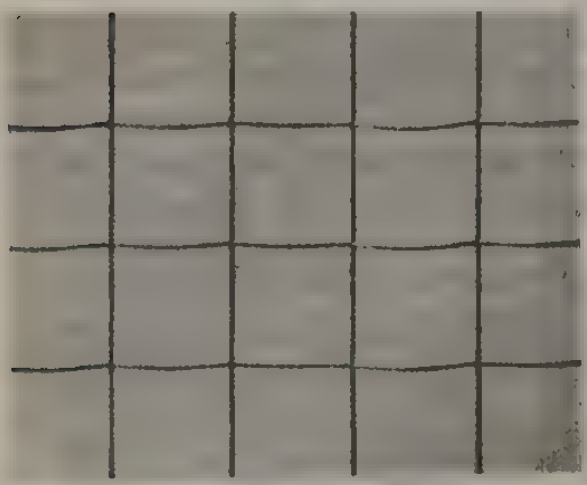
*Based on setting glass from inside and working from floor.

**Based on setting glass from outside, using glazing compound or steel sash putty.

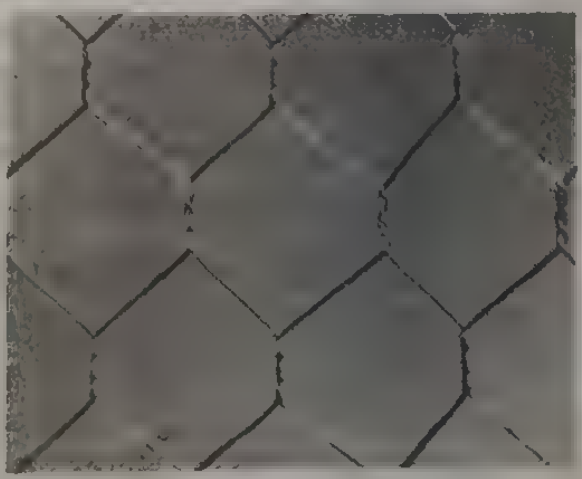
Crossweld Mottled Wired
¼" thick in sheets to 72"x130"
86% light transmission



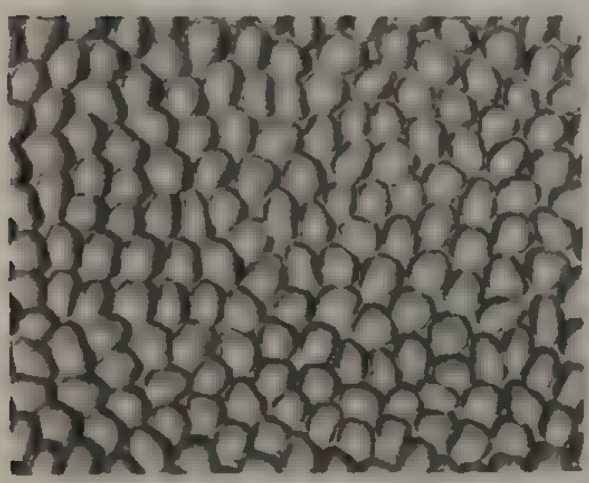
Hex Mottled Wired
¼" thick in sheets to 72"x130"
86% light transmission



Crossweld Polished Wired
¼" thick in sheets to 72"x98"
86% light transmission



Hex Polished Wired
¼" thick in sheets to 72"x98"
86% light transmission

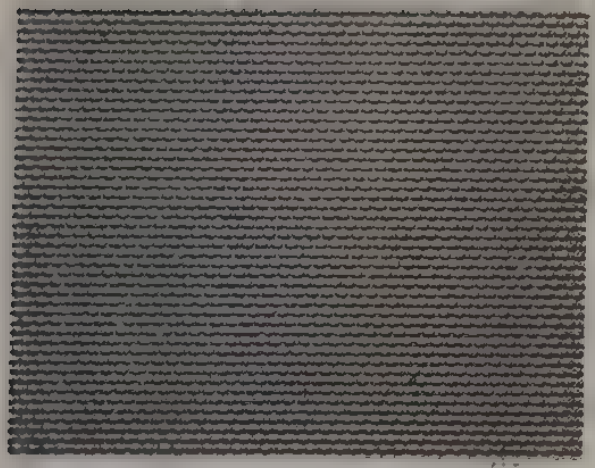


Hammered
⅛" and 7/32" thick in sheets to 96"x132"
90% light transmission

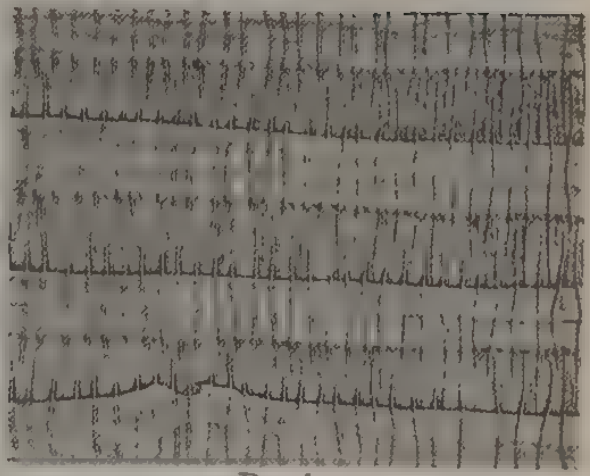
Surf
⅛" and 7/32" thick in sheets to 96"x132"
90% light transmission

Patterned Glass

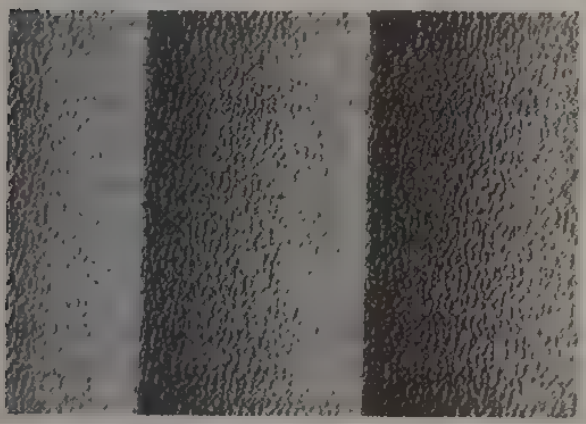
Courtesy Libbey-Owens-Ford Glass Co.



Crossnet
1/8" and 7/32" thick in sheets to 96"x132"
90% light transmission

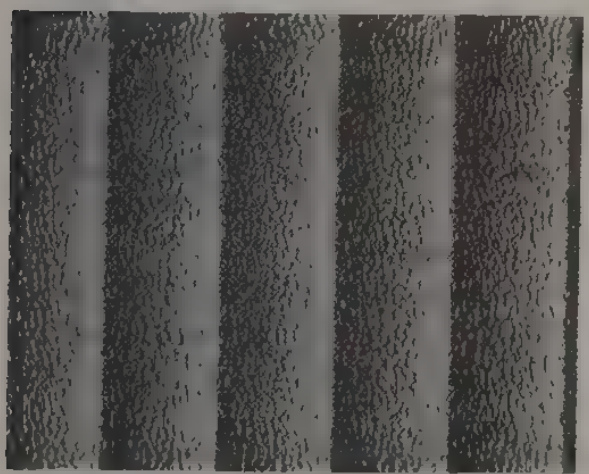


Bamboo
7/32" thick in sheets to 96"x132"
90% light transmission



Textured Colonnade
7/32" thick in sheets to 96"x132"
90% light transmission

Colonnade
7/32" thick in sheets to 96"x132"
90% light transmission



Textured Doric
1/8" and 7/32" thick in sheets to 96"x132"
90% light transmission

Doric
1/8" and 7/32" thick in sheets to 96"x132"
90% light transmission

Patterned Glass

Courtesy Libbey-Owens-Ford Glass Co.

If the high point of the roof is over 30 feet above the ground, it will require swing stage or scaffold and the rate of pay for every glazier on the job, whether working from the scaffold or not, must be increased 25 cts. per hour.

Steel Monitor Sash

Labor cost based on setting glass from comparatively flat roofs. If set from steep roofs costs will be increased slightly. If necessary to hoist glass, add up to 50 percent to costs given, as described above.

Monitor Sash Requiring Bedding but No Face Putty

Glass Size Inches	Number Lights per 8-Hr. Day	Glazier Hrs. per 100 Lts.	Lbs. Putty per Light
24"x36"	20	40.0	2.0
24"x48"	16	44.5	2.5
24"x60"	8	66.7	3.0
24"x72"	8	80.0	4.0
Monitor Sash Requiring Both Bedding and Face Putty			
24"x36"	12	53.3	4
24"x48"	12	66.7	5
24"x60"	6	80.0	6
24"x72"	6	100.0	8

Types of Glass.—Glass for glazing purposes is available in many types including sheet, plate and float, patterned, tempered, spandrel, insulating, laminated, heat absorbing, glare reducing, wired, bulletproof, corrugated and mirrored. Glass in block form is covered under the Masonry Section.

The price of glass is subject to frequent change due to fluctuation in costs of manufacture, supply and demand, and it is always advisable to consult your nearest jobber or dealer before quoting prices or submitting estimates. The estimator must also check to make certain that glazing of some items is now done at the factory as this is more and more the case, particularly with wood windows and special items such as sliding glass doors.

Price lists published by jobbers are usually quoted subject to discounts and include delivery of glass in dealer's immediate territory. For glass that must be shipped, freight boxing and handling charges must be added.

Sheet Glass.—Sheet glass is usually called for as "SS", single strength or $\frac{3}{32}$" thick, or "DS", double strength or $\frac{1}{8}$" thick. It can also be had in $\frac{3}{16}$", $\frac{7}{32}$", $\frac{1}{4}$", $\frac{3}{8}$" and $\frac{7}{16}$" thicknesses. Some sheet glass is specified by trade name and is of one quality, or as "AA" for extra high grade work; "A" for ordinary high grade work, and "B" for ordinary work.

In addition, sheet glass comes as picture glass, only $\frac{1}{16}$" thick and not suitable for glazing, and greenhouse glass, $\frac{1}{8}$" thick but of poorer quality and in small sizes of up to only 20"x24". Sheet glass can also be furnished with a grey tint for glare reduction in thicknesses from $\frac{3}{16}$" to $\frac{7}{32}$".

Sheet glass is available in the following maximum sizes and square foot costs:

SS	$\frac{3}{32}$"	40"x50"	$0.40
DS	$\frac{1}{8}$"	60"x80"	$0.46
	$\frac{3}{16}$"	120"x84"	$0.65
	$\frac{7}{32}$"	120"x84"	$0.85

It is also sometimes available in $\frac{3}{8}$" and $\frac{7}{16}$" thicknesses with a maximum size of 60"x84". Sheet glass may have either side set in or out, but for best appearance and visibility, the wave in the glass should run horizontally and the estimator should plan for this.

Plate Glass.—Plate glass is available in its transparent form as float, clear plate, and for heat reduction with a grey, bluish-green or bronze color; and in its translucent form as rough plate, regular or tinted. Maximum sizes are:

$\frac{1}{4}$" float	122"x200"
$\frac{1}{8}$" regular	76"x128"
$\frac{1}{4}$" "	127"x226"
$\frac{5}{16}$" "	127"x226"
$\frac{3}{8}$" "	125"x281"
$\frac{1}{2}$" "	125"x281"
$\frac{3}{4}$" "	120"x280"
1" "	74"x148"
$\frac{1}{8}$" tinted	84"x120"
$\frac{1}{4}$" "	124"x214"
$\frac{3}{8}$" "	120"x280"
$\frac{1}{2}$" "	120"x278"

Costs will run $1.05 a sq. ft. for $\frac{1}{4}$" clear, $1.35 and up for tinted.

In modernizing store front work, the estimator should investigate the possibilities of salvage allowance on existing plate glass as this is usually allowed if glass is in good condition. Sometimes the architect will specify plate glass in sizes larger than those listed above or in special bent shapes. These are available on special order only and often incur special boxing and shipping charges; the estimator should always secure a firm price for such items.

Patterned Glass.—Glass can be rolled or figured for decoration and light diffusion. Patterns vary from manufacturer to manufacturer but usually include sandblasted, hammered, ribbed, fluted, pebbled, and rough hammered designs. It is usually available in two thicknesses:

⅛" in 48"x132" maximum size
7/32" in 60"x132" maximum size

Some patterns available from Owens-Illinois are illustrated on the accompanying pages. Costs approximate $1.30 per sq. ft. for ⅛" thicknesses, $1.50 for 7/32".

Wired Glass.—Wire glass is a protective type glass for use in fire doors and windows, skylights, and other places where breakage is a problem. It is available in ¼" thicknesses in sheets 60"x144" maximum size in hexagonal, square, diamond and pin stripe patterns, and come in clear, hammered and many other patterned glass. Patterned wire glass will cost around $1.00 a sq. ft. Polished plate glass will run $2.00 a sq. ft.

Tempered Glass.—Tempered glass is a heat treated annealed glass which has high mechanical strength. It is 4½ to 5 times as strong as annealed glass of the same thickness. When it is broken, it disrupts into innumerable small fragments of a cubical shape. In recent years, tempered glass has become much more reasonable in cost and should be given more consideration in general construction. However, the nature of its manufacture does not allow cutting or drilling on the job and all fabricating must be done prior to heat treatment. It is available in clear and rough plate, tinted and heat absorbing. One-quarter inch thick units are available in sizes to 72"x120". As this glass is all custom ordered, costs should be checked locally, but tempering will add around $1.50 a sq. ft. to plate glass prices.

Laminated Glass.—Laminated or "safety" glass is composed of two or more lites of glass with a layer or layers of tough, transparent vinyl plastic sandwiched between the glass under heat and pressure to form a single unit. Laminated glass will crack but almost always will hold together. It is available in a wide range of thicknesses and sizes from 3/64" thick with a maximum size of 7 sq. ft. to 1" thick in sheets up to 72"x138". One-quarter inch laminated window glass will run around $2.35 a square foot while ¼" laminated plate glass will run $3.50 a square foot.

Insulating Glass.—Glass units made from two sheets of glass with a sealed air space between are used to decrease heat loss through windows. Glass can be either sheet or plate; seal can be either metal or glass, and air space will vary from 3/16" to ½".

Insulating glass units must be made to order in the exact size to be used although standard sizes are manufactured.

They require a slightly larger allowance for clearance in setting them into the rabbet than single lights of glass.

Each piece weighs about 2½ times what a single light of the same thickness would weigh and the glazing cost is about double that of single lights.

The price per square foot varies widely, depending upon kind of glass, size of lights, etc., so it is always advisable to obtain definite prices on the sizes required.

However, the following prices applying to standard sizes will furnish an idea as to the cost of Thermopane of various sizes. Prices in non-standard sizes will be higher.

Bondermetic Seal.*—Two or more lights of glass separated by ¼" or ½" of dehydrated captive air, hermetically sealed at the edges with a metal to glass bond.

Glasseal.*—Two panes of sheet glass separated by 3/16" of dehydrated captive air, hermetically sealed at the edges by fusing together the two glass panes.

Bondermetic

2 panes of ¼" polished Parallel-O-Plate/Float ½" air space. 6.5 lbs. per sq. ft.

Width	Height	Prices
33 "	x 76¾ "	$ 72.00
35½ "	x 36 "	35.50
35½ "	x 48⅛ "	48.25
35½ "	x 60⅜ "	60.15
42 "	x 66 "	72.00
42 "	x 72 "	78.00
44½ "	x 36 "	45.00
44½ "	x 48⅛ "	61.00
44½ "	x 60⅜ "	73.50
45 "	x 76¾ "	85.00
45⅜ "	x 52 "	63.00
46⅛ "	x 52½ "	70.00
47¾ "	x 50⅜ "	65.00
48 "	x 48 "	61.00
48 "	x 60 "	74.00
48½ "	x 42 "	60.00
48½ "	x 46 "	60.50
48½ "	x 50 "	65.00
48½ "	x 58 "	74.00
50⅜ "	x 60⅛ "	81.00
55¼ "	x 36 "	53.00
55¼ "	x 48⅛ "	72.00
55¼ "	x 60⅜ "	87.00
56½ "	x 42 "	64.00
56½ "	x 46⅛ "	67.50
56½ "	x 50 "	74.50
56½ "	x 58⅛ "	87.00
56½ "	x 66 "	100.00
57 "	x 76¾ "	110.00
58⅛ "	x 52½ "	95.00
64½ "	x 46 "	78.00

*Libby-Owens-Ford Glass Co.

Bondermetic—(Continued)

Width	Height	Prices
64½ "	x 50 "	$ 83.00
64½ "	x 58 "	100.00
64½ "	x 66 "	112.00
66⅝ "	x 47¾ "	82.50
66⅝ "	x 60⅛ "	109.00
68¾ "	x 36 "	67.00
68¾ "	x 48⅛ "	85.00
68¾ "	x 60⅜ "	111.50
70⅛ "	x 52½ "	101.50
70⅛ "	x 56½ "	108.00
72 "	x 48 "	87.00
72 "	x 60 "	120.00
72½ "	x 46 "	86.00
72½ "	x 50 "	97.50
72½ "	x 58 "	111.00
72½ "	x 66 "	124.00
75 "	x 36 "	72.50
75 "	x 48⅛ "	100.00
75 "	x 60⅜ "	120.00
80½ "	x 50 "	107.00
80½ "	x 58 "	121.50
84 "	x 66 "	138.50
84 "	x 72 "	153.00
93 "	x 36 "	88.00
93 "	x 48⅛ "	121.00
93 "	x 60⅜ "	145.50
96 "	x 66 "	160.00
96 "	x 72 "	172.50
96½ "	x 50 "	126.00
96½ "	x 58 "	142.50
116½ "	x 58 "	173.00

2 panes of DSA window glass ¼" air space.

Width	Height	Prices
21¾ "	x 62¾ "	$ 26.64
22 "	x 28 "	14.92
22 "	x 36 "	17.95
25¾ "	x 62¾ "	29.15
30¼ "	x 22 "	16.42
31½ "	x 11⅜ "	12.18
31½ "	x 35½ "	22.87
42½ "	x 22½ "	18.40
45½ "	x 25½ "	21.12

Standard sliding door sizes 1 lt. grey plate ¼", 1 lt. clear plate ¼", ½" air space, 1" thick.

33 "	x 76¾ "	$ 86.68
45 "	x 76¾ "	125.01

2 lts. .200 plate, ¼" air space ⅝" thick.

28 "	x 76 "	$ 39.54
33 "	x 76¾ "	41.89
34 "	x 76 "	40.91
45 "	x 76¾ "	53.65
46 "	x 76 "	52.42

2 lts. 3/16" plate "Tufflex" ¼" air space, ⅝" thick.

28 "	x 76 "	$ 65.25
33 "	x 76¾ "	69.13
34 "	x 76 "	67.51
45 "	x 76¾ "	88.53
46 "	x 76 "	86.48

Glasseal

DSA window glass with 3/16" air space (thickness .437"± .050") 3.3 lbs. per sq. ft.

Width	Height	Prices
28 7/16"	x 66 "	$ 44.00
35 7/16"	x 36 1/16"	24.10
36⅝ "	x 49¼ "	42.90
39⅝ "	x 49¼ "	44.20
41⅝ "	x 43¼ "	42.23
44⅝ "	x 49¼ "	48.28

SSA window glass with 3/16" air space (thickness .375"± .050") 2.4 lbs. per sq. ft.

Width	Height	Prices
16 "	x 24 "	$ 9.37
16 "	x 32 "	11.69
16 "	x 36 "	12.86
16 "	x 48 "	16.47
16 "	x 60 "	20.20
16 3/16"	x 24⅝ "	10.15

Glasseal—(Continued)

Width	Height	Prices
16 9/16"	x 30 13/16"	$ 11.89
16 9/16"	x 36 13/16"	13.66
16 9/16"	x 49 "	17.18
16 9/16"	x 61 3/16"	21.53
19 "	x 15 "	7.78
19 1/2 "	x 53 "	20.27
20 "	x 16 "	8.29
20 "	x 20 "	9.49
20 "	x 22 "	10.15
20 "	x 24 "	10.75
20 "	x 28 "	11.98
20 "	x 32 "	13.21
20 "	x 36 "	14.50
20 "	x 48 "	18.45
20 "	x 60 "	22.54
20 1/2 "	x 31 15/16"	13.92
20 1/2 "	x 44 "	17.95
20 1/2 "	x 55 7/8 "	22.30
21 1/16"	x 24 5/8 "	11.78
21 1/16"	x 30 13/16"	13.99
21 1/16"	x 36 13/16"	15.96
21 1/16"	x 49 "	19.96
21 1/16"	x 61 3/16"	24.56
22 "	x 18 "	9.45
22 "	x 55 9/16"	22.42
24 "	x 22 "	11.38
24 "	x 24 "	12.07
24 "	x 28 "	13.43
24 "	x 32 "	14.81
24 "	x 36 "	16.11
24 "	x 48 "	20.80
24 "	x 60 "	25.21
27 1/4 "	x 14 1/4 "	10.27
27 1/4 "	x 18 1/4 "	$11.69
27 1/4 "	x 22 1/4 "	13.02
27 1/4 "	x 30 1/4 "	16.11
28 "	x 16 "	10.57
28 "	x 22 "	12.63
28 "	x 28 "	14.80
32 "	x 22 "	13.92
32 "	x 28 "	16.18
35 7/16"	x 36 1/16"	21.78
36 "	x 22 "	15.21
36 "	x 28 "	17.89
36 5/8 "	x 14 1/4 "	12.80
36 5/8 "	x 18 1/4 "	14.49
36 5/8 "	x 22 1/4 "	16.19
36 5/8 "	x 30 1/4 "	19.79
39 5/8 "	x 14 1/4 "	13.63
39 5/8 "	x 18 1/4 "	15.37
39 5/8 "	x 22 1/4 "	17.35
39 5/8 "	x 30 1/4 "	21.11
40 "	x 16 "	14.02
40 "	x 20 "	15.74
40 "	x 22 "	16.74
40 "	x 24 "	17.72
40 "	x 28 "	19.30
42 1/2 "	x 22 1/2 "	18.40
44 "	x 16 "	15.16
44 3/8 "	x 31 15/16"	23.95
44 5/8 "	x 14 1/4 "	15.13
44 5/8 "	x 18 1/4 "	17.16
44 5/8 "	x 22 1/4 "	19.04
44 5/8 "	x 30 1/4 "	23.37
45 1/2 "	x 25 1/2 "	21.13

On special sizes of Glasseal there is no savings over Bondermetic on orders under 500 units.

LEADED AND ART GLASS

When estimating leaded or art glass, odd or fractional parts of inches are charged as even inches of the next larger size; for example, a 12¼"x13¼" light will be charged as 14"x14".

Circles, ovals or irregular patterns will be charged at the rate

of a square or rectangle which will contain them.

The following prices are based on leading, using zinc cames not over ⅜" wide:

	Price per Sq. Ft.
Rectangles and squares, Clear sheet glass	$ 3.75
Rectangles and squares, Cathedral glass, white or colored	$4.00 to 15.00
Rectangles or squares, Plate glass	5.25
Diamonds, Clear sheet glass	4.25
Diamonds, Cathedral glass, white or colored	$5.00 to 20.00
Diamonds, Plate glass	6.30

Colored Art Glass Leaded.—Leaded art glass furnished in colors may be had in many designs at $6.00 to $10.00 a square foot, which includes only straight work.

Landscape and water scenes in colored art glass will run from $15.00 to $25.00 a square foot.

Very elaborate designs of art glass in colors with flowers, fruits, etc., may be purchased at from $35.00 up per sq. ft.

The architect usually specifies an allowance of so much per square foot to cover the cost of all art glass in the building.

Cost of Boxing Leaded or Art Glass.—Boxing either leaded or colored art glass is charged for at the rate of 25 cents a square foot of actual lid measurement of cases shipped, but the minimum charge for any box is 75 cents.

SPANDREL GLASS

Vitrolux is heat-strengthened ¼" polished plate glass for spandrels and other opaque panels of curtain walls. The glass is coated on the back with a ceramic frit to give opacity and color. The color is sunfast and the peminence is similar to that of ordinary glass.

Vitrolux is manufactured in seventeen standard colors, plus black and white, but can be ordered in almost any color desired.

Spandrel glass is factory cut to size (job cutting is not possible due to the heat-strengthening process in manufacturing), and must be set in the rabbets to prevent the material from becoming load bearing. Therefore it is necessary to have removable stops on all four sides; the material must be set on setting blocks, at ¼ points of the bottom edge; and must have ⅛" to ¼" gloss face to stop face clearance both inside and out established by spacer shims.

Sealing of spandrel glass is usually accomplished by the use of liquid polysulphide sealants and neoprene gaskets.

Prices on spandrel glass installed in Chicago and vicinity only.

The following prices include the removal and replacing of glazing stops, the spandrel glass set with glazing tape, and sealed with liquid polysulphide sealant.

Quantity Sq. Ft.	Prices per Sq. Ft. Standard Colors	Non-Standard Colors
100–1000	$3.81 + $150.00 Set Up	$4.01 + $400.00 Set Up
1000–3000	3.81	4.01
3000 Plus	3.56	3.56

The above prices do not include any scaffolding or hoisting charges.

STRUCTURAL GLASS

Carrara Glass.—These structural glasses are opaque and non-absorbent. They are used for walls of bathrooms, kitchens, powder rooms, wainscoting, counters and table tops in restaurants, drug stores, hospitals, urinal stalls, faces of store fronts and for many purposes where marble is used.

Prices on Structural Glass

The following prices are for Carrara glass, polished one side, rough one side, and all prices are net.

	Prices per Square Foot 11/32"	7/16"	¾"	⅞"	1¼"
Black	$1.92	$2.40	$3.92	$6.50	$12.30
White	2.88	3.20	4.31	7.15	13.50
Field Colors*	3.06	3.52	...	8.08	14.80

*Ivory, gray, tranquil green, beige.

Honed finish in black only, same price as regular finish.

Trim colors, made in $\frac{11}{32}$" thickness only, are dark blue, forest green, wine, gun metal and shell pink. Price $3.06 per sq. ft.

For suede finish, add 30 cts. per sq. ft.

All footage and edge work computations to be made on next higher even inch basis.

No size to be estimated as less than 6 inches wide or containing less than one sq. ft.

Prices for Drilling Holes

Size of Hole	Thickness of Glass ¼"	11/32"	7/16"	¾"
To and including ½"	$0.18	$0.33	$0.35	$0.40
⅝" holes and over	.62	.91	.98	1 10

Prices for Edge Work Per Lineal Inch

	¼" and 11/32"	7/16"	¾"	⅞"	1¼"
Polished	$0.075	$0.093	$0.163	$0.175	$0.39
Ground	.025	.046	.08	.093	.20
Mitered, Ground	.043	.065	.14	.225	.35
Mitered, Polished	.093	.12	.223	.25	.54
Polished with ¼" Round	.081	.10	.20	.225	.475
Quarter Round and Polished	.10	.125	.215	.30	.52
Polished with polished bevel* ½"	.15	.188	.325	.35	.775
Ground with Polished Arris	.044	.063	.125	.131	.20
Cut with Ground Arris	.013	.025	.063	.075	.10

*Width of bevel not to exceed the thickness of the glass.

Mirrors

The finest mirrors are copper backed plate glass usually mounted on masonite backs with stainless steel clips so mirrors can be hung either direction. These may be ordered with bevelled or plain polished edges.

Size	Cost Bevelled	Plain
20"x20"	$ 7.75	$.....
24"x24"	10.05	.....
20"x30"	11.10	10.25
24"x30"	12.50	11.15
24"x36"	15.20	14.50
30"x30"	15.55	.....
30"x40"	19.90	.....
30"x48"	24.65	23.65
36"x48"	29.05	28.25
36"x54"	33.40	30.70
36"x60"	37.45	35.10
12"x48"	10.05	9.40
16"x68"	17.55	15.50
20"x68"	20.95	19.25
22"x68"	23.65	29.95
24"x68"	25.65	23.65

METAL STORE FRONT CONSTRUCTION

Metal store fronts constructed of alumilited aluminum alloy, both drawn and extruded, and of stainless steel in drawn members only, are extensively used for display windows, as they provide the greatest display space with the least obstruction, which places them in high favor with all who use windows for display purposes.

In the larger cities, the metal store fronts are usually erected by the concern furnishing the materials, while in the smaller cities and towns, store front erection is usually performed by carpenters.

Method of Estimating Metal Store Fronts.—To arrive at the amount of material required to construct any store front, the number of lineal feet of each class of material should be estimated separately and priced at the current price per lin. ft. To compute the length of metal required, add the following to glass dimensions for joints and miters:

Sill, transom bar and jamb coverings, add	4″
Sash (complete sash or stop only), add	2″
Corner, division and reverse bars, add	0″

Prices of Standard (Rolled or Light Extruded) Metal Store Front Material

Metal is sold f.o.b. shipping point, except when sold with plate glass, when full freight is allowed.

Stainless steel furnished in rolled sections only.

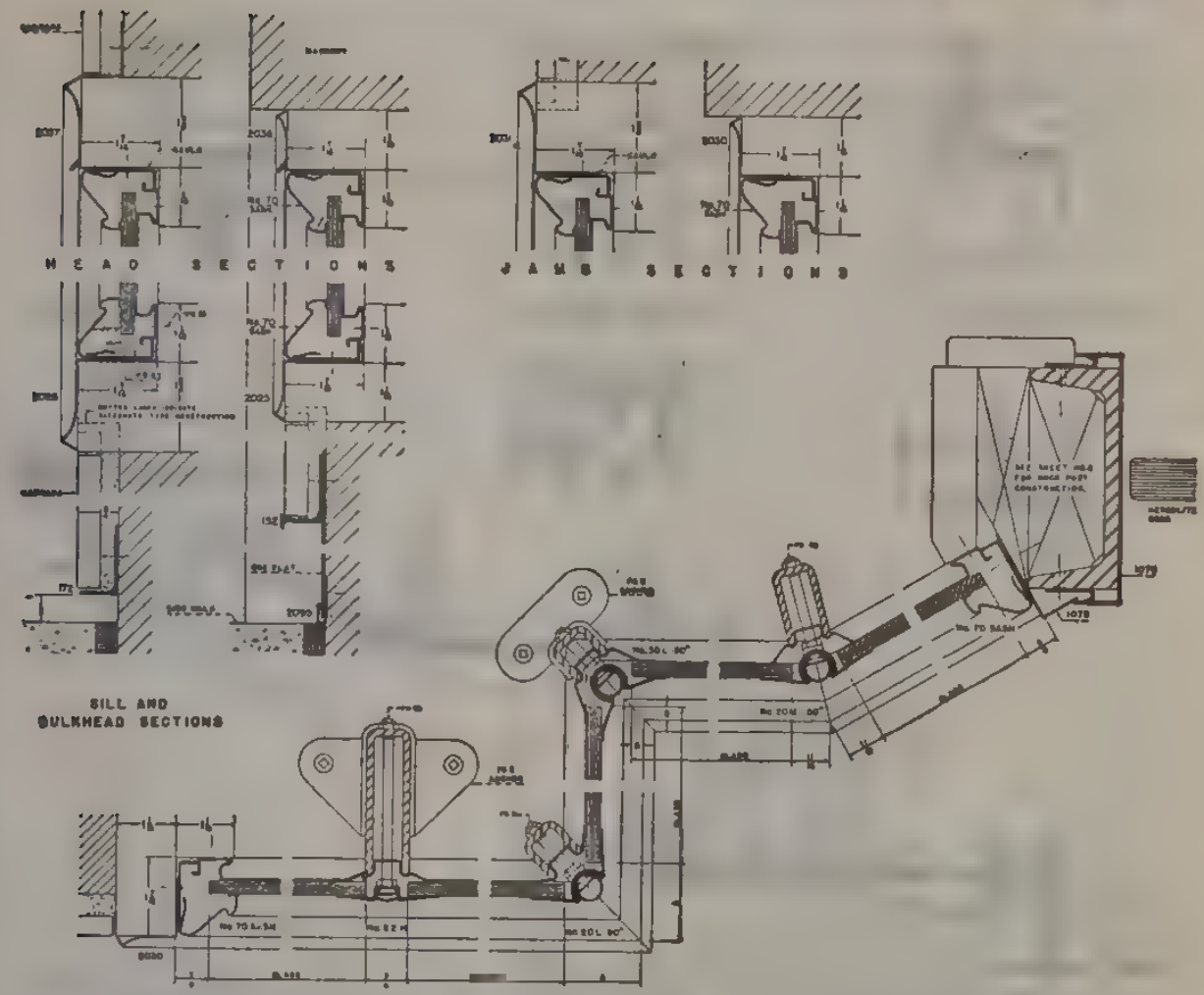
	Price Per Lin. Ft.	
	Alumilite	Stainless Steel
Metal Sash		
Regular	$1.15	$ 2.10
Self supporting	1.15	2.10
Transom	1.30	2.40
Jamb	1.60	2.10
4″ cover	1.50	3.70
Corner Bars		
Not over 4′-0″ high (90 to 170 degrees)	$1.50	$ 2.60
Not over 8′-0″ high (90 to 170 degrees)	1.65	2.90
Over 8′-0″ high (90 to 170 degrees)	1.95	3.00
Extra reinforced (90 to 170 degrees)	3.80	5.50
Tubular back (90 to 170 degrees)	7.50	10.00

	Price Per Lin. Ft. Alumilite	Stainless Steel
Division Bars		
Not over 4′-0″ high	$1.50	$ 2.55
Not over 8′-0″ high	1.65	2.75
Over 8′-0″ high	1.95	2.90
Extra reinforced	3.80	5.40
Tubular back	7.50	10.00
Reverse Angle Corner Bars		
Not over 4′-0″ high (90 to 170 degrees)	$1.60	$ 2.70
Not over 8′-0″ high (90 to 170 degrees)	1.80	2.85
Over 8′-0″ high (90 to 170 degrees)	2.10	3.10
Extra reinforced (90 to 170 degrees)	5.50	6.50
Three-Way Bar	$3.20	$ 4.70
Transom Bar Covering, 1⅝″ high	1.30	2.15
Head Jamb Covering, 1⅝″ high	.70	1.65
Side Jamb Covering, 1⅝″ wide	.65	1.75
Sill Covering, 1⅝″ high	.65	1.75

Prices of Standard (Rolled or Light Extruded) Metal Store Front Material

	Price Per Lin. Ft. Alumilite	Stainless Steel
Wide Transom Bar Covering		
1⅝″ extension molding	$0.75	$0.95
4″ covering	1.50	3.70
6″ covering	1.80	4.20
8″ covering	2.35	5.00
10″ covering	2.80	5.90
12″ covering	3.55	6.90
Awning Transom Bar (Steel Hood Type)		
10″ awning cover	$5.25	$8.85
End caps (specify right or left) each	6.00	7.50
Splice caps each	2.50	3.85
Corner splice caps (specify angle) each	2.50	4.30

The above prices are approximate and will vary depending on shape.



Details of Rolled or Light Extruded Metal Store Front Materials.

Curved Material

Sash and rolled moldings under 6" in girth will be charged for at 5 times price for straight material.

"S" curves charged at 10 times price of straight material.

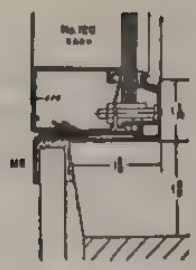
Metal to be bent must not exceed 10 feet in length.

A minimum charge of $14.00 will apply for each curved item which, computed on the prescribed basis, does not equal that amount.

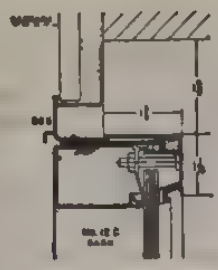
Molding over 6" in girth and curves under 18" radius, special prices.

Prices on Heavy Extruded Store Front Material

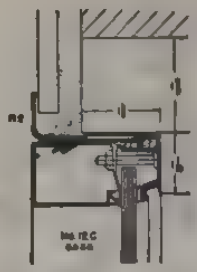
Member	Price Per Lin. Ft. Alumilite
Sash	$1.70
Corner bar, same as standard members	1.65
Division bar, same as standard members	1.65
Division bar, heavy duty, same as standard members	2.20
Reverse bar, same as standard members	1.80
Three-way bar, same as standard members	3.20



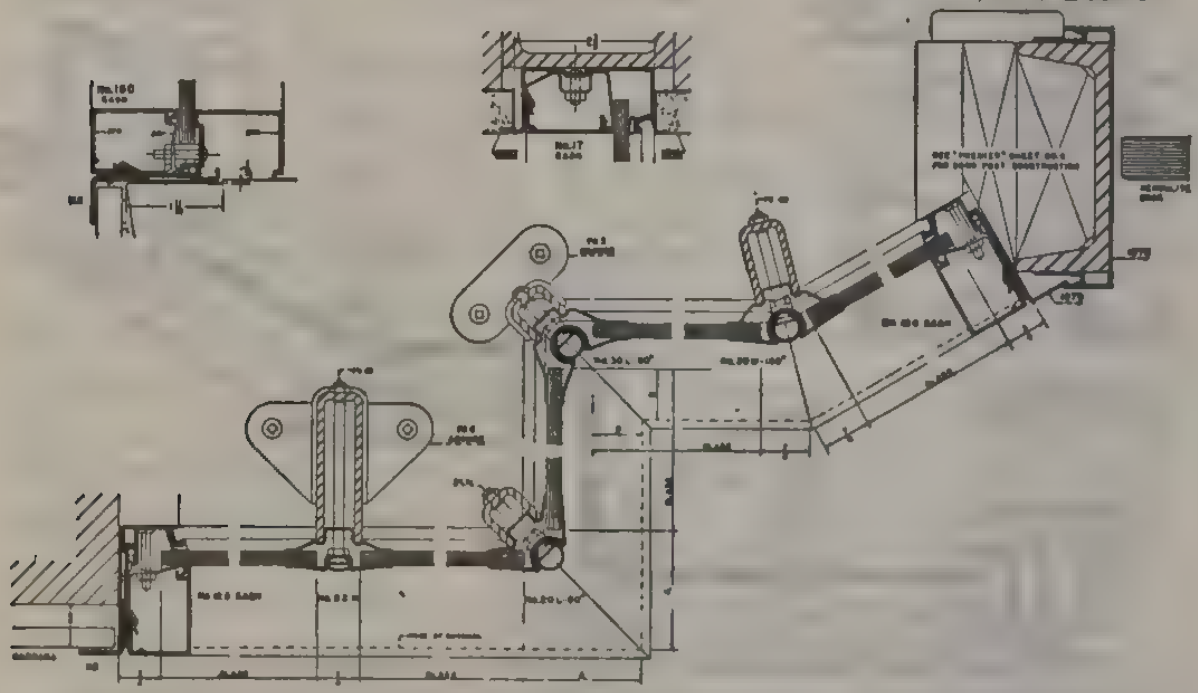
Sill Section



Head Section



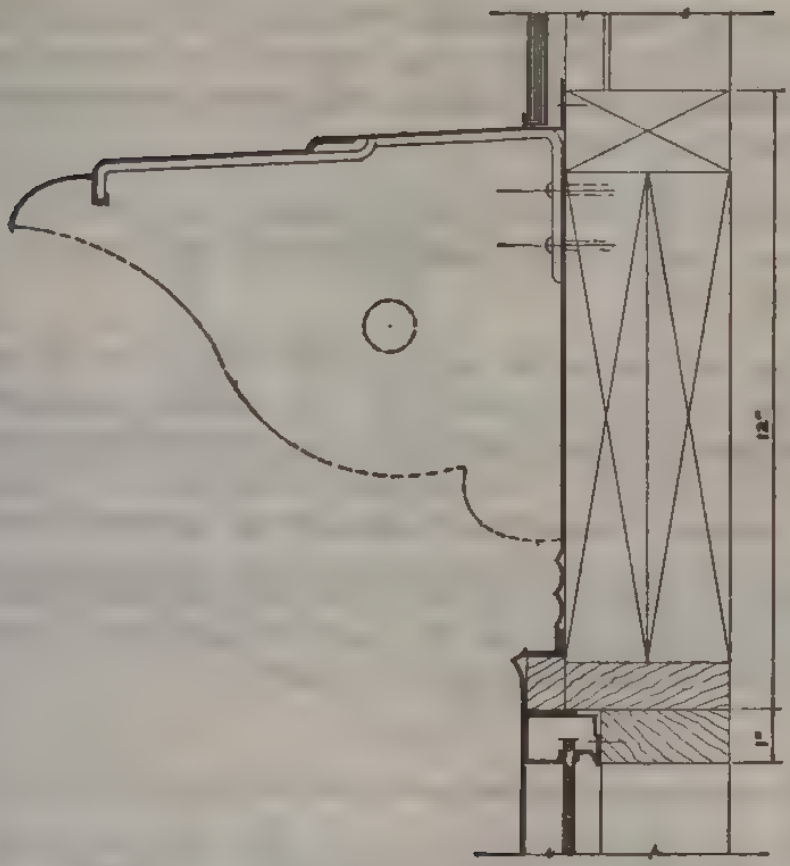
Jamb Section



Details of Heavy Extruded Metal Store Front Materials.

Prices on Heavy Extruded Store Front Material

Member	Price Per Lin. Ft. Alumilite
Sill covering, 1⅝"	$1.60
Head or side jamb covering, 1⅝"	1.70
Transom bar covering, 1⅝"	1.85
Transom bar covering, 4"	2.95
Transom bar covering, 6"	3.70
Transom bar covering, 7⅛"	4.40
Transom bar covering, 9⅛"	5.20
Transom bar covering, 11⅛"	5.90
Awning covering, 9½"	9.20
End caps (specify right or left) ..... each	7.05
Splice caps ..... each	.85
Corner splice plates (specify angle) ..... each	3.05



Awning Cover Used in Metal Store Front Construction.

Actual prices can only be determined by application.

Curved Material.—Rules regarding curved material in connection with rolled members apply to extruded members.

Minimum radius for curved extruded members is 16".

Accessories such as setting blocks and screws are included without extra charge.

In both regular and extruded fronts, there will be an extra charge of 45 cts. each for bar anchors and 65 cts. each for sash caps.

Free-Standing Door Frame.—A free-standing door frame, overall size 6'-5"x7'-2½", with a pair of 3'-0"x7'-0" doors, as shown on Store Front No. 2, should cost about $900.00, f.o.b. shipping point.

Tubular Doors.—The metal for one pair of Tubular doors, 2'-8"x7'-0", with a transom 46" high, as shown in store front No. 4, complete with frame and glass stops; doors complete with door closers, push and pull bars, locks, etc., should cost about $1500.00, f.o.b. shipping point.

Labor Erecting Metal Store Fronts.—The labor cost of installing metal store fronts will vary with the style of front, size, etc., as the larger and more elaborate the front the more labor required to install it.

In the larger cities metal store fronts are installed by sheet metal workers but in the smaller cities and towns carpenters usually install them.

There is no set rule for estimating the cost of metal store fronts by the lin. ft. of material. A certain number of hours should be allowed for an average size store front for each type of construction and a proportionate addition or deduction for a larger or smaller store front should be figured therefrom.

The following costs cover installation of the metal portions of the store front only and do not include any woodwork or carpentry labor in connection with same.

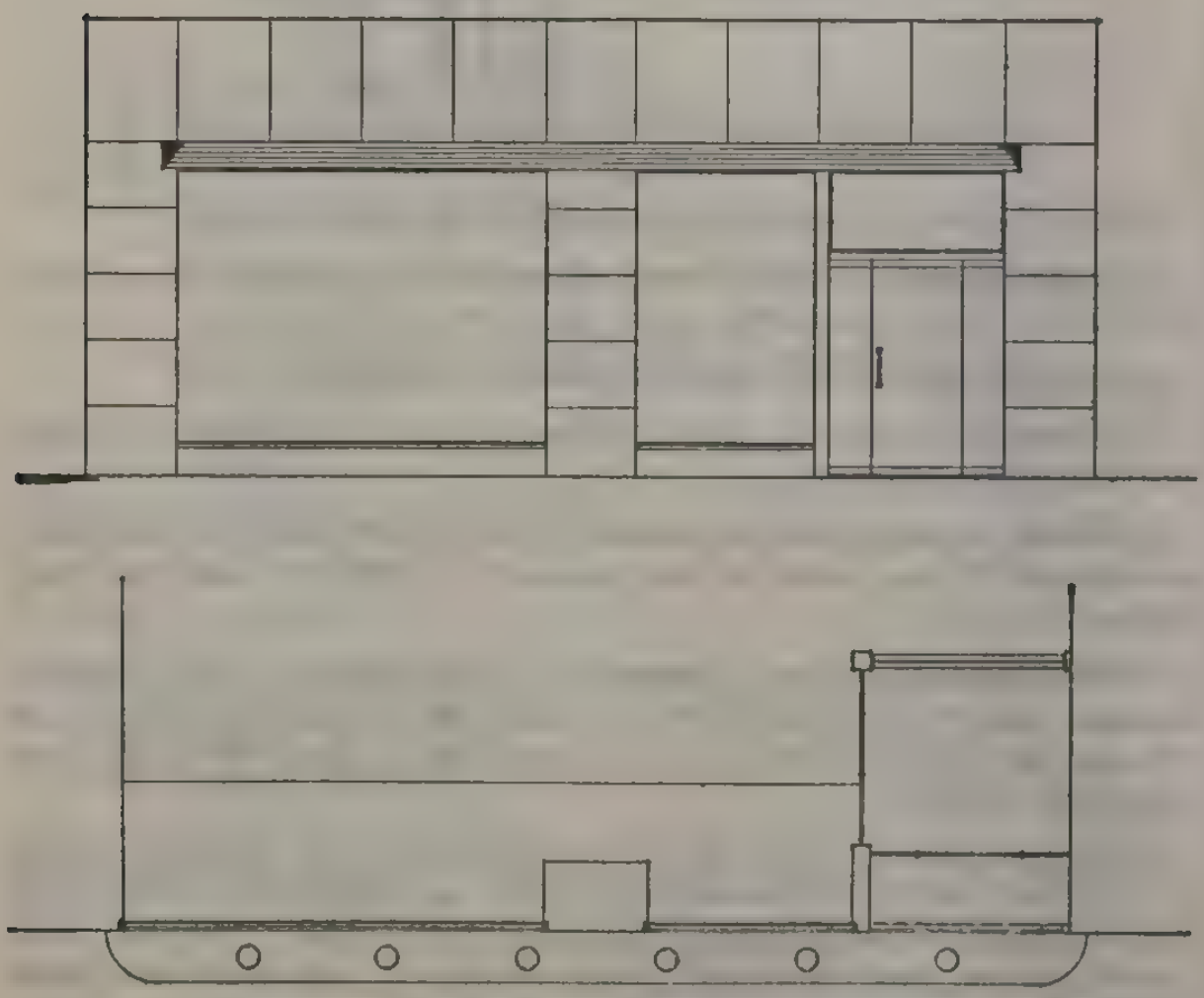


Figure 1. Metal Store Front Construction.

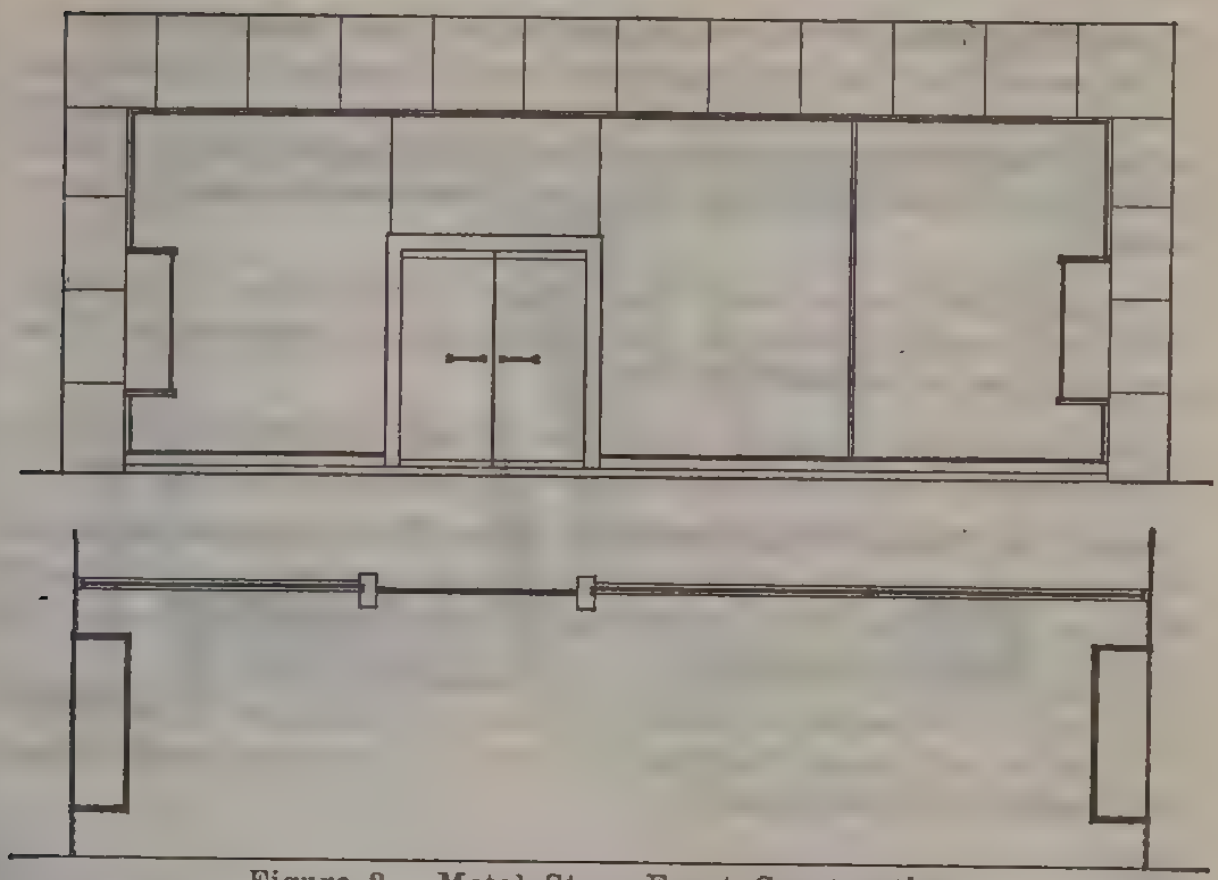


Figure 2. Metal Store Front Construction.

Installing Metal Work for Metal Store Front Similar to No. 1. —The metal for this front includes sash, sill covering, canopy face and deck and the soffit undercover at the door.

To install all metal work for a front of this type, 28 to 30 ft. wide, will require about 65 hrs. time for an experienced carpenter or sheet metal worker.

The above time is based on the use of heavy extruded metal. If rolled members are used, the metal work should be installed in 35 to 40 hrs.

Installing Metal Work for Metal Store Front Similar to No. 2. —The metal work for this front includes sash, covering for head, side jambs, sills and for the bulk head, division bar and metal as indicated for the two side cases.

To install all metal work for a front of this type, 32 to 36 ft. wide, will require about 105 hrs. for an experienced sheet metal worker or carpenter.

The above time is based on the use of rolled members. If heavy extruded members are used. it would require about 160 hrs.

Installing Metal Work for Metal Store Front Similar to No. 3. —The metal for this front includes sash, covering for side jamb and sill, corner and dividing bars, awning hood (but no awning), full soffit under cover in the vestibule, bulk head cover (exterior and interior) and covering for posts, transom and head in the doorway.

To install all metal work for a front of this type, 26 to 30 ft. wide, will require about 85 hrs. time for an experienced sheet metal worker or carpenter.

The above time is based on the use of rolled members. If heavy extruded members are used, it would require about 120 hrs.

Installing Metal Work for Metal Store Front Similar to No. 4. —The metal for this front includes sash, covering for sill and side jamb, awning box for concealed awning with lid and lid operator (but no awning).

To install all metal work for a front of this type about 20 to 24 ft. wide, will require about 105 hrs. for an experienced sheet metal worker or carpenter.

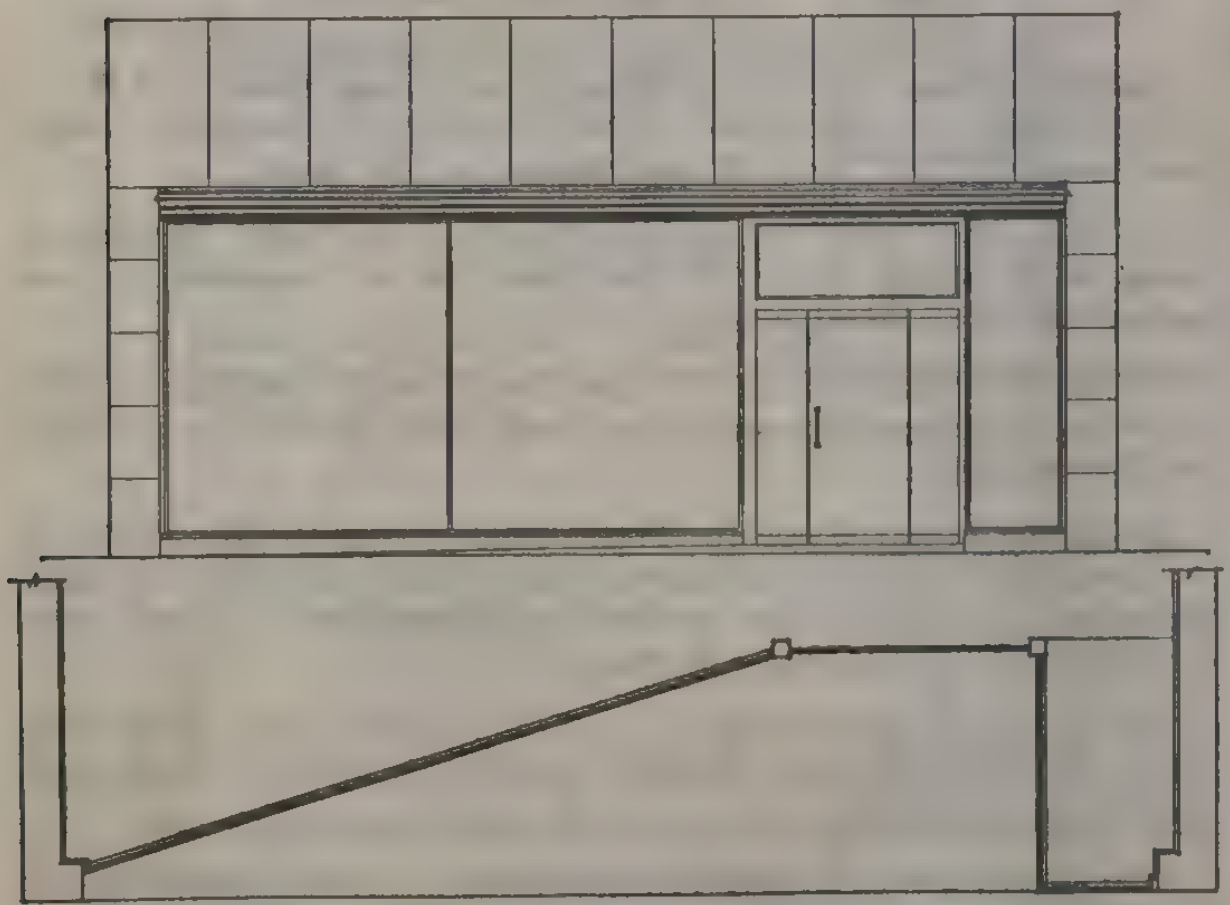


Figure 3. Metal Store Front Construction.

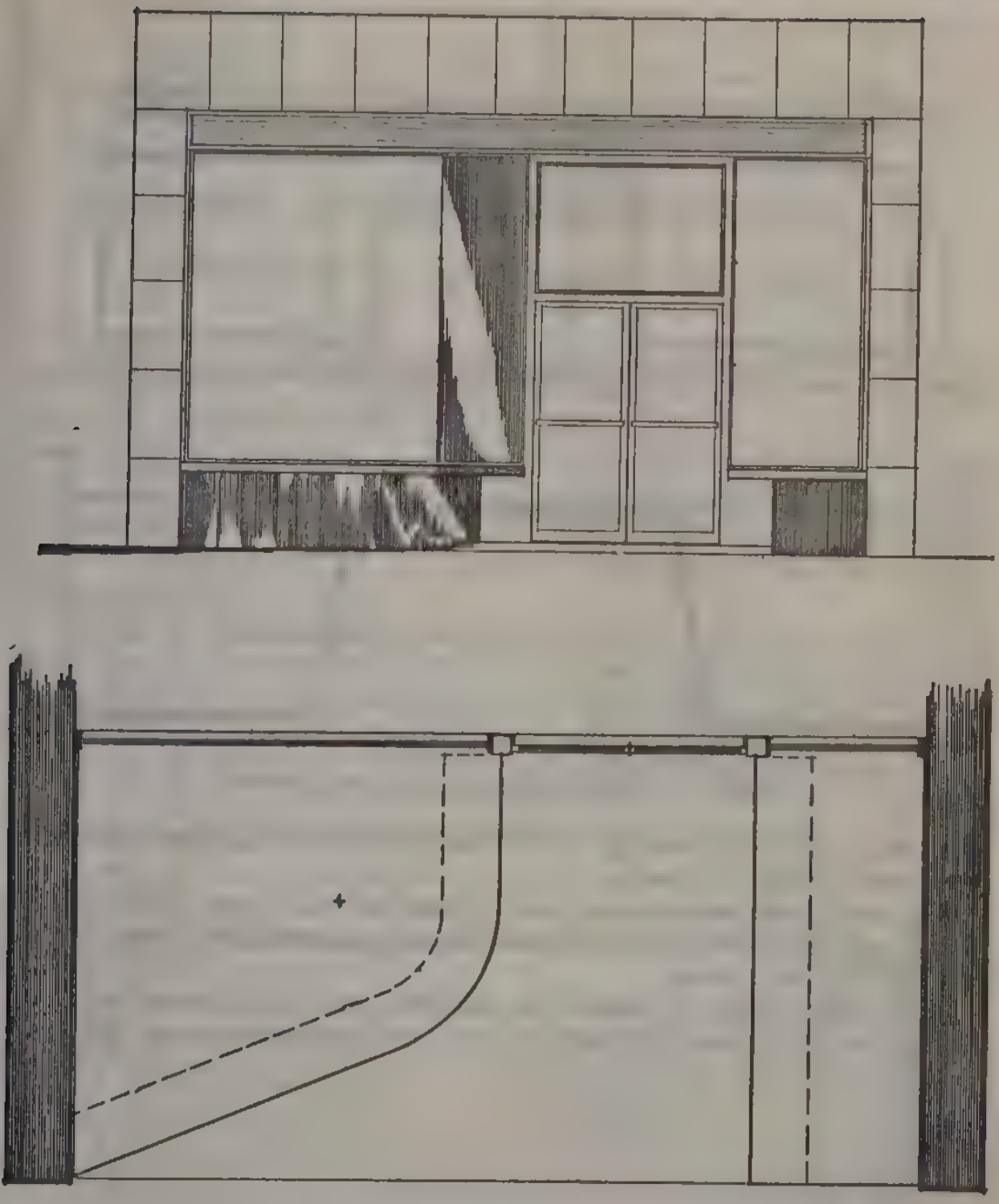


Figure 4. Metal Store Front Construction.

The above time is based on the use of heavy extruded members. If rolled members are used, it would require about 65 hrs.

Installing Metal Work for Metal Store Front Similar to No. 5. —The metal for this front includes sash, covering for sills, side jambs and transom, recessed awning box with hinged lid and

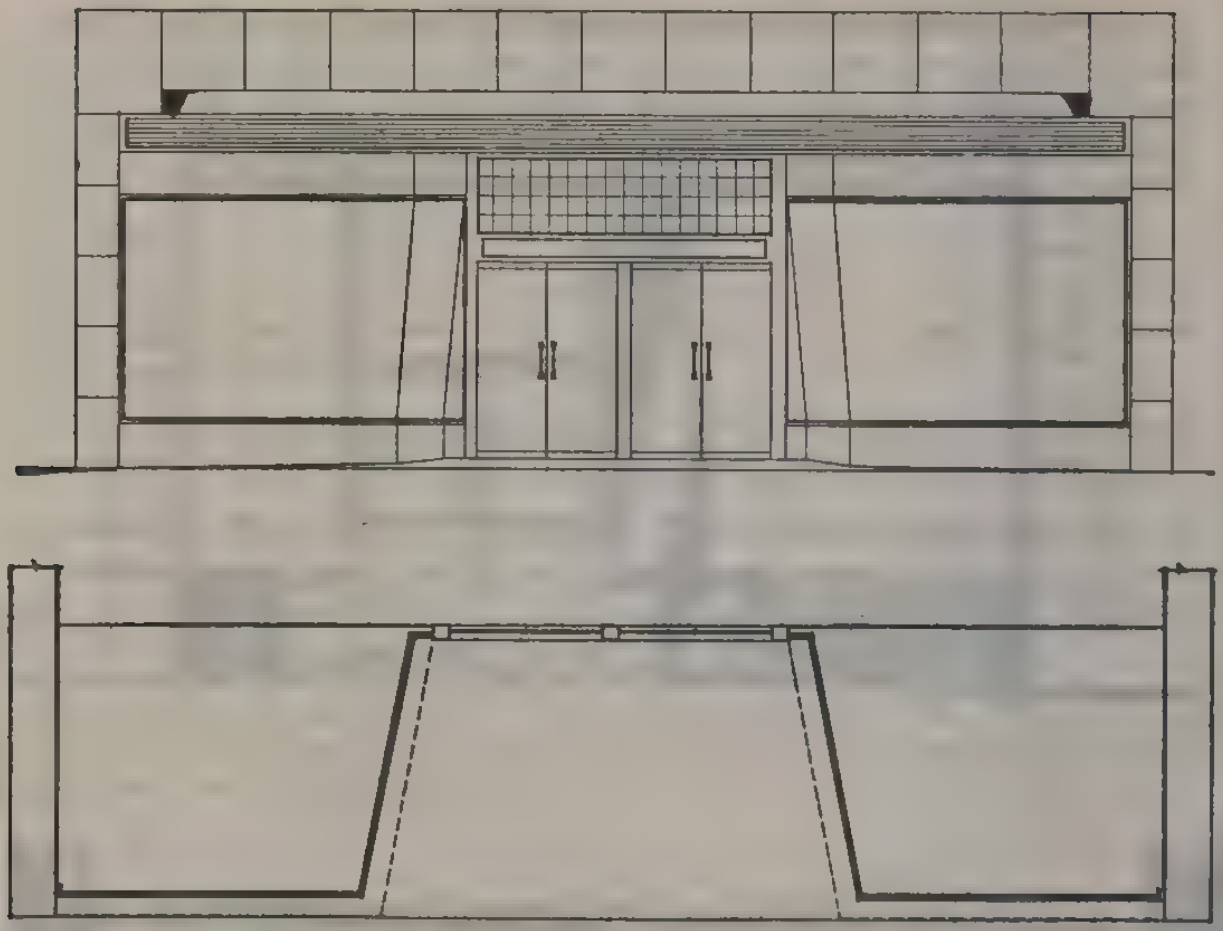


Figure 5. Metal Store Front Construction.

operators (but no awning), covering for posts, transom head and mullions in the doorway.

To install all metal work on a front of this type, 40 to 44 ft. wide, will require about 205 hrs. for an experienced sheet metal worker or carpenter.

The above time is based on the use of rolled members. If heavy extruded members are used, it will require about 300 hrs.

CHAPTER XXI

ROOFING, CORRUGATED ASBESTOS AND METAL ROOFING AND SIDING

Roofing is estimated by the square containing 100 sq. ft. The method used in computing the quantities will vary with the kind of roofing and the shape of the roof.

The labor cost of applying any type of roofing will be governed by the pitch or slope of the roof, size, plan of same (whether cut up with openings, such as skylights, penthouses, gables, dormers, etc.), and upon the distance of the roof above the ground, etc.

Rules for Measuring Flat Roofs.—When measuring flat roof surfaces that are to be covered with composition, tar and gravel, tin, metal or prepared roofing, the measurements should be taken from the outside of the walls on all four sides to allow for flashing up the side of each wall. The flashing is usually 8" to 1'-0" high. This applies particularly to brick, stone or tile buildings having parapet walls above the roof level.

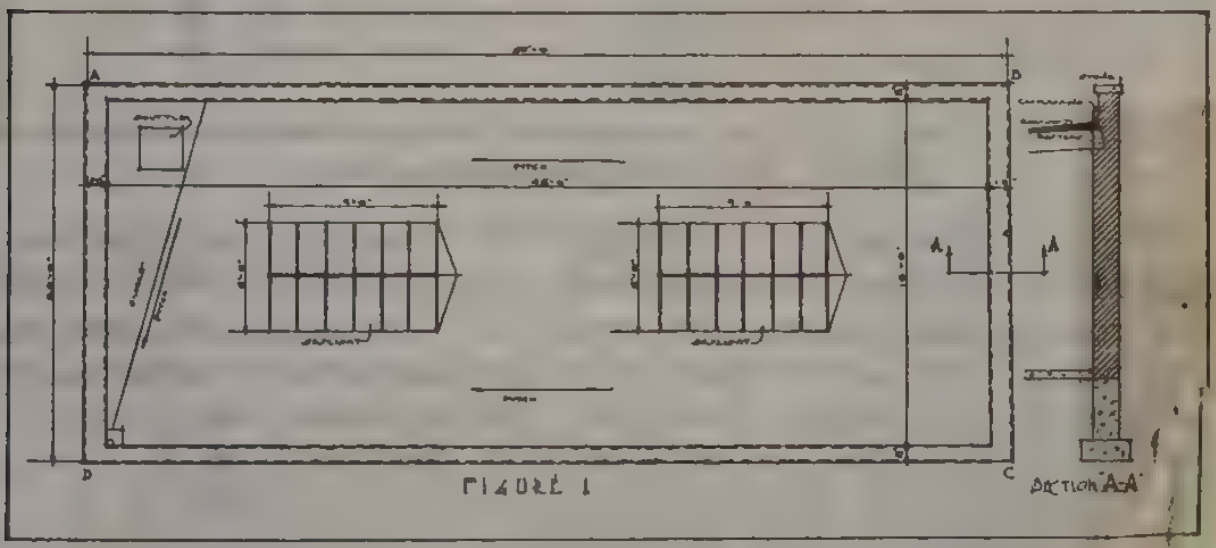


Fig. 1. Flat Roof with Parapet Walls

On flat roofs projecting or overhanging beyond the walls of the building, the measurements should cover the outside dimensions of the roof and not merely to the outside of the walls.

When estimating the area of flat roof surfaces, do not make deductions for openings containing less than 100 sq. ft. and then deductions should be made for just one-half the size of the opening.

Make deductions in full for all openings having an area of 500 sq. ft. or more.

Example: The length of the building (as shown in Figure 1), is 50′-0″, which is the distance from A to B. The width of the building from B to C is 20′-0″. Multiplying the length by the width, 50x20=1,000 sq. ft. By referring to Figure 1, you will note the building is only 48′-0″ long and 18′-8″ wide between walls. The method of measuring the full length and width of the building is to allow for flashing up the side of the walls, which usually extends 8″ to 12″ high.

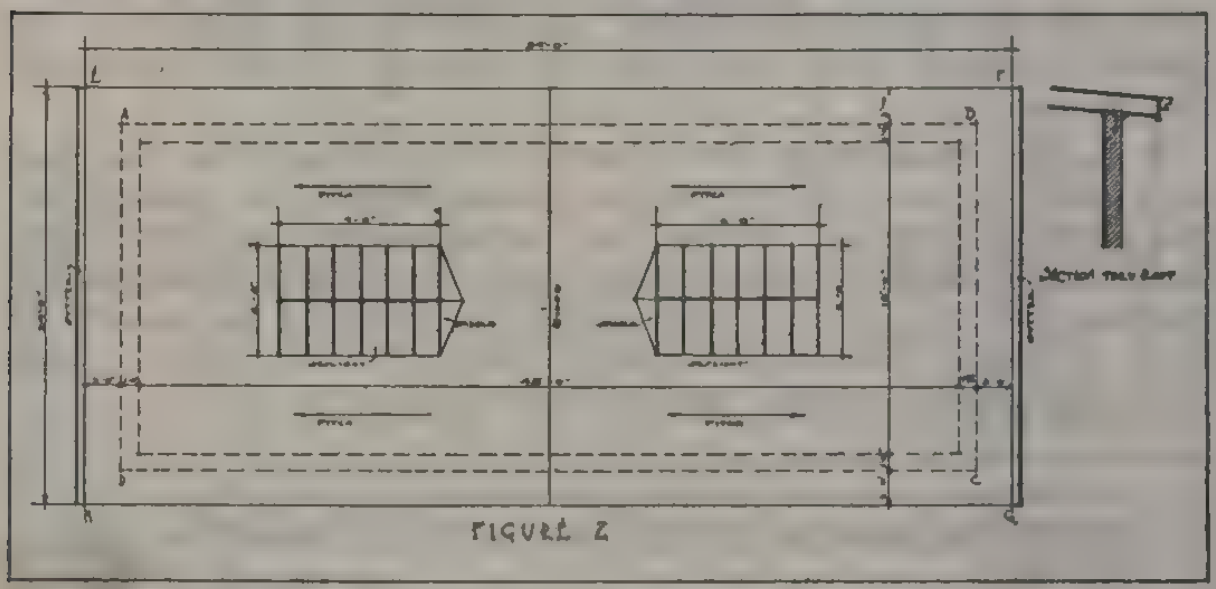


Fig. 2. Flat Roof Overhanging Walls

Figure 2 illustrates a building of the same size with projecting roof. The size of the building proper is 20′-0″x50′-0″, while the roof projects beyond the walls 2′-0″ on each side, making the size of the roof 24′-0″x54′-0″. The roof area is obtained by multiplying the length of the roof (the distance from E to F), 54′-0″, by the width of the roof (the distance from F to G), 24′-0″, making the total roof area, 54′-0″x24′-0″=1,296 sq. ft.

The skylights on both roofs measure 6′-0″x9′-0″ and contain only 54 sq. ft. each, so no deduction should be made for these openings, as they contain less than 100 sq. ft. each and the extra labor flashing up the sides of the walls more than offsets the cost of the small openings.

Rules for Measuring Plain Double Pitch or Gable Roofs.—To obtain the area of a plain double pitch or gable roof as shown in Figure 3, multiply the length of the ridge (A to B), by the length of the rafter (A to C). This will give the area of one-half the roof. Multiply this by 2 to obtain the total sq. ft. of roof surface.

Example: Assume the length of the ridge (A to B), is 30′-0″ and the length of the rafter (A to C), 20′-0″. By multiplying (A to B), 30′-0″ by (A to C), 20′-0″ equals 600. The area of one-half the roof is 600 sq. ft. 600x2=1,200 sq. ft. of roof.

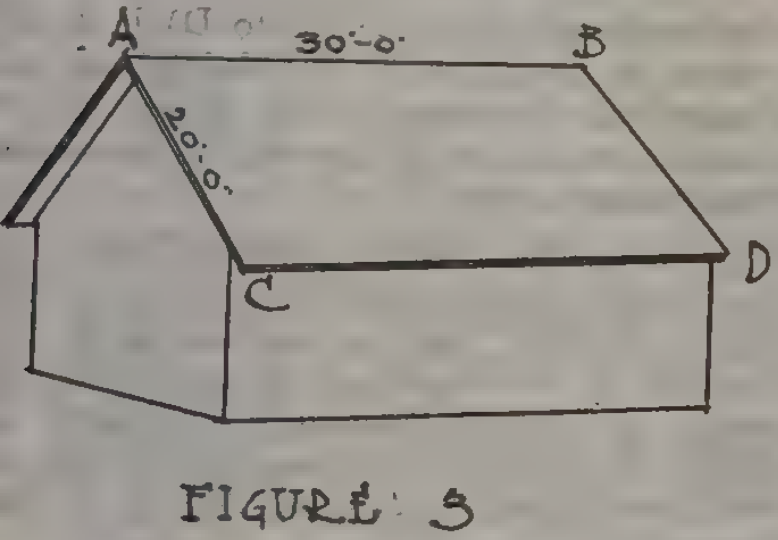


FIGURE 3

Fig. 3. Plain Double Pitch or Gable Roof

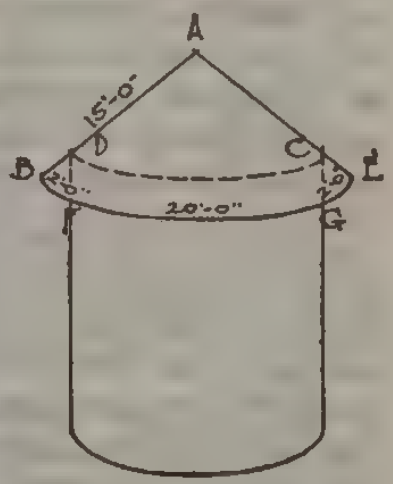


Fig. 6. Conical Building and Roof

Rules for Measuring Hip Roofs.—To obtain the area of a hip roof as shown in Figure 4, multiply the length of the eaves (C to D)) by ½ the length of the rafter (A to E). This will give the number of sq. ft. of one end of the roof, which multiplied by 2 gives the area of both ends. To obtain the area of the sides of the roof, add the length of the ridge (A to B) to the length of the eaves (D to H). Divide this sum by 2 and multiply by the length of the rafter (F to G). This gives the area of one side of the roof and when multiplied by 2 gives the number of sq. ft. on both sides of the roof.

To obtain the total number of sq. ft. of roof surface, add the area of the two ends to the area of the two sides. This total divided by 100 equals the number of squares in the roof.

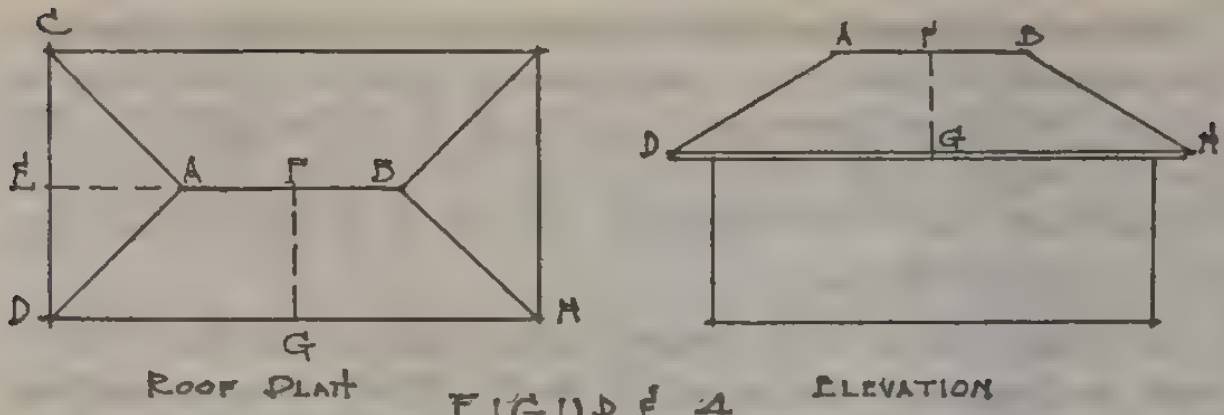


FIGURE 4

Fig. 4. Hip Roof

Example: Assume the length of the eaves (C to D) is 20′-0″ and the length of the rafter (A to E) is 20′-0″. Multiplying (C to D) 20′-0″ by ½ the length of the rafter (A to E), or 10′-0″ equals 200 sq. ft., the area of one end of the roof. To obtain the area of both ends, 200x2=400 sq. ft.

To obtain the area of the sides of the roof, the length of the ridge (A to B), is 10′-0″ and the length of the eaves (D to H), is 30′-0″. Add (A to B) 10′-0″ to (D to H) 30′-0″, and the result is 40′-0″. By taking ½ the combined length of the ridge and eaves, ½ of 40′-0″ =20′-0″, the average length of the roof. Assuming the length of the rafter (F to G) as 20′-0″, 20′-0″x20′-0″=400 sq. ft., the area of one side of the roof, which multiplied by 2 equals 800 sq. ft., the area of both sides of the roof.

Adding the area of the two ends to the area of the two sides gives 1,200 sq. ft. of roof area.

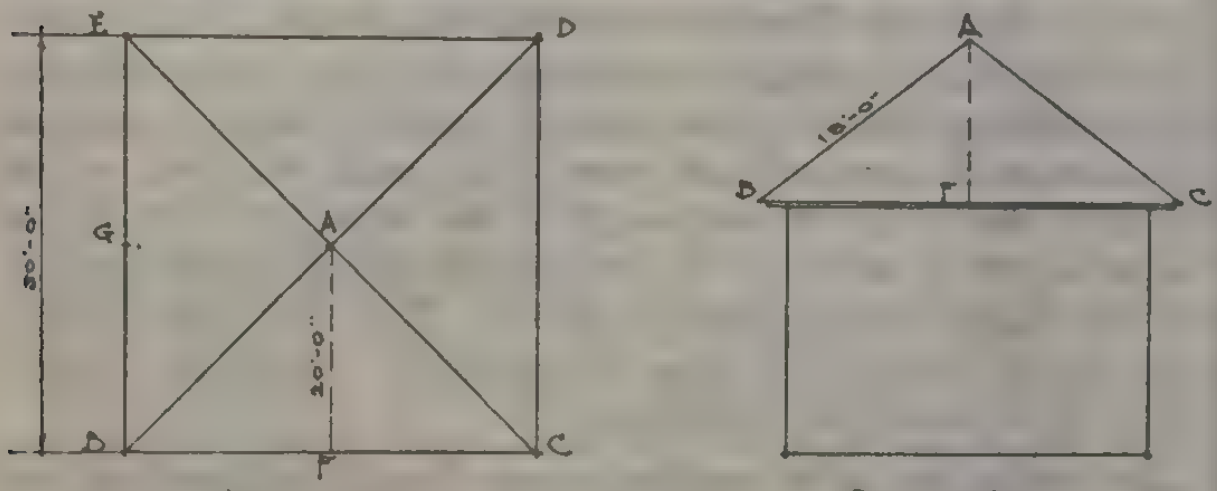


FIGURE 5

Fig. 5. Hip Roof

The area of a plain hip roof running to a point at the top is obtained by multiplying the length of the eaves (B to E) by ½ the length of the rafter (A to F). This gives the area of one end of the roof. To obtain the area of all four sides, multiply by 4.

Example: Multiply the length of the eaves (B to E), which is 30′-0″, by ½ the length of the rafter (A to F), 10′-0″, and the result is 300 sq. ft., the area of one end of the roof. 300x4=1,200 sq. ft., the area of the 4 sides.

Rules for Measuring Conical Tower Roofs and Circular Buildings.—To obtain the area of a conical tower roof as shown in Figure 6, multiply ½ the length of the rafter (A to B) by the distance around the eaves at B. As an example, assume the length of the rafter (distance from A to B) is 15′-0″ and the diameter of the building at B is 20′-0″.

To obtain the distance around the building, multiply the diameter by 3⅐ or 3.1416. If the eaves project beyond the outside walls, and the diameter is given only to the outside walls of the building, add the length of the roof projection on both sides of the building to obtain the correct diameter. Example: If the diameter of the building (C to D) is 20′-0″ and the eaves project 2′-0″ on each side, the diameter of the building at the eaves would be 24′-0″.

Multiplying 24′-0″ (B to E), the diameter of the building at eaves, by 3.1416, gives 75.3984, or approximately 75′-5″ around the eaves at projection (B to E).

To obtain the area of the roof, multiply ½ the length of the rafter (A to B), which is 15′-0″, (½ of 15 is 7½) or 7′-6″, by the distance around the eaves at B and E, which is 75′-5″ or 75.4 feet, and the result is 565.5, or 565½ sq. ft., the area of the roof.

To obtain the area of a cylindrical or circular building, multiply the height by the circumference, or the distance around the building, and the result will be the number of sq. ft. to be covered. The circumference is obtained by multiplying the diameter (C to D) of the building by 3⅐, or 3.1416. To obtain the area of the outside walls of a cylindrical building whose diameter is 20′-0″ and the height 15′-0″, 20x3.1416=62.832, or 62′-10″. Multiply 62.832 ft. (the distance around the building) by 15 ft. (the height of the building)=942.48, or 942½ sq. ft., the area of the outside walls.

A Short Method of Figuring Roof Areas

To obtain the number of square feet of roof area, where the pitch (rise and run) of the roof is known, take the entire flat or horizontal area of the roof and multiply by the factor given be-

low for the roof slope applicable and the result will be the area of the roof.

Always bear in mind, the width of any overhanging cornice must be added to the building area to obtain the total area to be covered.

Example: Find the area of a roof 26'-0"x42'-0, having a 12" or 1'-0" overhanging cornice. Roof having a ¼ pitch or a 6 in 12 rise and run.

To obtain the roof area, 26'-0" + 1'-0" + 1'-0" = 28'-0" width. 42'-0" + 1'-0" + 1'-0" = 44'-0" length. 28x44 = 1232 or 1,232 sq. ft. flat or horizontal area.

To obtain area at ¼ pitch or 6 in 12 rise and run: multiply 1,232 by 1.118 = 1377.376 or 1,378 sq. ft. of roof surface.

Add allowance for overhang on dormer roofs and sides.

Pitch of Roof	Rise and Run	Multiply Flat Area by	Lin. Ft. of Hips or Valleys per Lin. Ft. of Common Run
1/12	2 in 12	1.014	1.424
1/8	3 in 12	1.031	1.436
1/6	4 in 12	1.054	1.453
5/24	5 in 12	1.083	1.474
1/4	6 in 12	1,118	1.500
7/24	7 in 12	1.158	1.530
1/3	8 in 12	1.202	1.564
3/8	9 in 12	1.250	1.600
5/12	10 in 12	1.302	1.612
11/24	11 in 12	1.357	1.685
1/2	12 in 12	1.413	1.732

Hips and Valleys. — The length of hips and valleys, formed by intersecting roof surfaces, running perpendicular to each other and having the same slope is also a function of the roof rise and run. For full hips or valleys, i.e. where both roofs intersect for their full width, the length may be determined by taking the square root of the sum of the rise squared plus twice the run squared.

Using the factors given in the last column of the above table, the length of full hips or valleys may be obtained by multiplying the total roof run from eave to ridge, (not the hip or valley run), by the factor listed for the roof slope involved.

WOOD SHINGLES

Complete estimating data on wood shingles for roofs and sidewalls is given under "Rough Carpentry."

ASPHALT SHINGLES

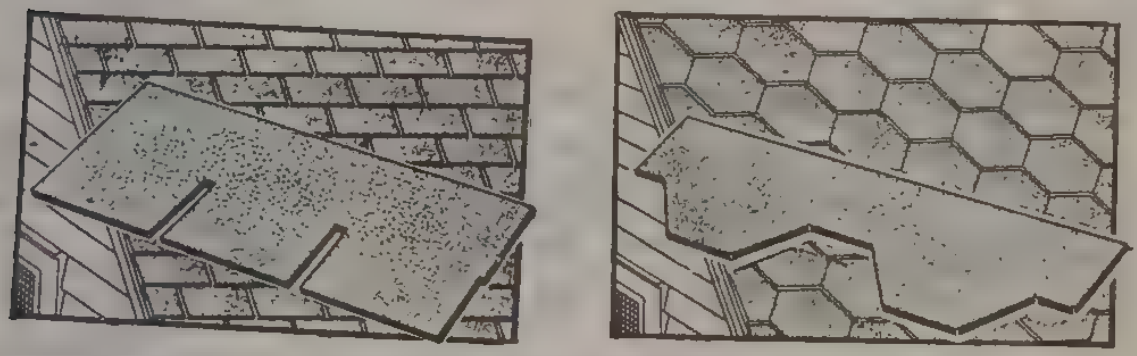
Asphalt shingles are furnished in several styles and the labor

cost of laying them will vary with the style of shingle used and the type of roof to which they are applied.

Individual asphalt shingles are furnished and laid in exactly the same manner as wood shingles, the only difference being their size.

Strip asphalt shingles are furnished in strips, each containing 3 shingles, so when laying them a man handles and lays 3 shingles at a time.

Hexagon asphalt shingles are furnished in strips $11\frac{1}{3}$"x36".



Strip Asphalt Shingles

Estimating Quantities of Asphalt Shingles.—Asphalt shingles are sold by the square containing sufficient shingles to cover 100 sq. ft. of roof.

When measuring roofs of any shape, always allow one extra course of shingles for the "starters" at the eaves, as the first or "starting" course of shingles must always be doubled.

Obtain the number of lin. ft. of hips, valleys and ridges to be covered with asphalt shingles and compute same as 1'-0" wide.

Many roofing contractors do not measure hips, valleys and ridges, preferring to add a percentage of the roof area to cover these items and waste. The following percentages are commonly used:

Gable roofs, 10 percent; hip roofs, 15 percent; hip roofs with dormers and valleys, 20 percent.

If the asphalt shingles are to remain on the roof during heavy wind storms, they must be properly nailed—6 nails to a strip and nailed low enough on the shingle (right at the cut-out), otherwise they will blow off the roof.

Most manufacturers produce a shingle, designed for high wind areas, that interlock in such a manner that all of the shingles are integrated into a single unit. Interlocking shingles are available in single coverage for re-roofing and double coverage for new construction.

Self-sealing shingles with adhesive tabs are also produced by most manufacturers.

When using asphalt shingles for roofs, roll asphalt roofing of the same materials as the shingles are often used for forming valleys, hips and roof ridges.

Nails Required for Asphalt Shingles.—When laying individual asphalt shingles, use a 12 ga. galvanized nail, 1½" long, with a $\frac{7}{16}$" head. For laying over old roofs, use nails 1¾" long.

When laying square butt strip shingles, use 11 ga. galvanized nails, 1" long, with a $\frac{7}{16}$" head. For laying over old roofs, use nails 1¼" long.

Sizes and Estimating Data on Asphalt Shingles

Kind of Shingle	Size	No. Shingles per Sq.	Expos. Inches	Length Nails	No. Nails per Shingle	Lbs. Nails per Sq.
3-in.-1 strip	12"x36"	80	5	1	4	1
3-in.-1 strip	15"x36"	80	5	1	4	1

Approximate Prices on Mineral Surfaced Asphalt Shingles

Kind of Shingle	Size	Weight per Square	Price per Square
3-in-1 strip	12"x36"	235 lbs.	$11.50
3-in-1 strip	12"x36"	300 lbs.	13.00
3-in-1 strip	12"x36"	250 lbs.	12.20
3-in-1 strip	15"x36"	315 lbs.	16.50
3-in-1 strip, self sealing	12"x36"	235 lbs.	13.00

Labor Laying Asphalt Shingles

Description of Work	No. Sq. Ft. 8-Hr. Day	Carpenter Hours per Sq.
Laying 12"x36" strip asphalt shingles on plain double pitch or gable roofs without hips, valleys or dormers.	375–425	2.0
Same as above except laid by experienced shinglers.*	575–625	1.4*
Laying 12"x36" strip asphalt shingles on double pitch or gable roofs having hips, valleys and dormers and requiring cutting and fitting.	315–365	2.4
Same as above except laid by experienced shinglers.*	475–525	1.6*
Laying 12"x36" strip asphalt shingles on difficult constructed hip roofs, requiring considerable cutting and fitting for hips, valleys, dormers.	300–350	2.5
Laying 15"x36" strip asphalt shingles, 5' exposed to the weather, 4 nails per shingle, will require about the same time as 12"x36" strip shingles.	450–500	1.7*

*For new work, add 1 sq. roll No. 15 saturated felt.

Cost of 100 Sq. Ft. (1 Sq.) 12"x36" Strip Asphalt Shingles on Plain Double Pitch or Gable Roofs

	Hours	Rate	Total	Rate	Total
1 sq. strip shingles.....		$.....	$.....	$11.50	$11.50
1 lb. 1" galv. nails.....		.....	.....	.25	.25
Carpenter	2	.....	.....	6.75	13.50
Cost per 100 sq. ft.....	2		$.....		$25.25

On roofs having gables, dormers, etc., add 0.4-hr. time per sq.

On difficult constructed hip or English type roofs, add 0.5-hr. time per sq.

If experienced shinglers are used, deduct 0.6-hr. from time given above.

Cost of 100 Sq. Ft. (1 Sq.) 15"x36" Strip Asphalt Shingles on Plain Double Pitch or Gable Roofs

	Hours	Rate	Total	Rate	Total
1 sq. strip shingles.....		$.....	$.....	$16.50	$16.50
1 lb. nails		.....	.....	.25	.25
Carpenter	2	.....	.....	6.75	13.50
Cost per 100 sq. ft.....	2		$.....		$30.25

If experienced shinglers are used, deduct 0.75-hr. from time given above.

On roofs having gables, dormers, etc., add 0.5-hr. time per sq.

On difficult constructed hip or English type roofs, add 0.6-hr. time per sq.

SLATE ROOFING

Roofing slate is furnished in a number of sizes, thicknesses and finishes to meet the architectural requirements of the buildings on which they are to be used. The four principal classifications are: standard slate; textural slate; graduated slate and flat slate roofs.

Standard Roofs.—Standard slate roofs are composed of slate approximately $\frac{3}{16}$" thick (commercial standard slate), of one uniform standard length and width; also one length and random widths or random lengths and widths. Any width less than one-half the length is not recommended. Standard roofs are suitable for any building where a permanent roofing material is desired at a minimum cost. If desired, the butts or corners may be trimmed to give a hexagonal, diamond or "Gothic" pattern for all or part of the roof.

Textural Roofs.—The term "textural" is used to designate slate of rougher texture than the standard, with uneven tails or butts and with variations of thickness or size. In general, this term is not applied to slate over $\frac{3}{8}$" in thickness.

Graduated Roofs.—The graduated roof combines the artistic features of the textural slate roof with additional variations in thickness, size and exposure. The slate is so arranged on the roof that the thickest and longest occur at the eaves and gradually diminish in size and thickness until the ridges are reached. Slate for roofs of this type can be obtained in any combination of thicknesses from $\frac{3}{16}$" to $\frac{3}{4}$" and heavier when especially desired.

In addition to the usual standard sizes, slate above $\frac{1}{2}$" thick are produced in lengths up to 24". The graduations in lengths generally range from 24" to 12". The longest slate are used at the eaves and the length usually diminishes with the thickness. The variations in length will at once provide a graduation in exposure by using the standard 3" lap. To illustrate, a suitable range of lengths might be:

Under Eaves Course	$\frac{3}{8}$" thick	14" long	No exposure
First Course	$\frac{3}{4}$" "	24" "	$10\frac{1}{2}$" "
1 "	$\frac{3}{4}$" "	24" "	$10\frac{1}{2}$" "
2 Courses	$\frac{1}{2}$" "	22" "	$9\frac{1}{2}$" "
2 "	$\frac{1}{2}$" "	20" "	$8\frac{1}{2}$" "
2 "	$\frac{3}{8}$" "	20" "	$8\frac{1}{2}$" "
4 "	$\frac{3}{8}$" "	18" "	$7\frac{1}{2}$" "
5 "	$\frac{1}{4}$" "	16" "	$6\frac{1}{2}$" "
3 "	$\frac{1}{4}$" "	14" "	$5\frac{1}{2}$" "
3 "	$\frac{3}{16}$" "	14" "	$5\frac{1}{2}$" "
8 "	$\frac{3}{16}$" "	12" "	$4\frac{1}{2}$" "

Random widths should be used and so laid that the vertical joints in each course are broken and covered by the slate of the course above.

Flat Roofs.—Flat roofs offer a wide field for roofing slate and are so designated whether or not they are used for "promenade" purposes.

Slate of any thickness may be used instead of slag or gravel as a surfacing material for the usual built-up type of roof. For ordinary roofs the standard $\frac{3}{16}$" slate are used but for promenade or extraordinary service, the slate should be $\frac{1}{4}$" or $\frac{3}{8}$" thick.

Slate for flat roofs are furnished in the following standard sizes: 6"x6", 6"x8", 6"x9", 10"x6", 10"x7", 10"x8", 12"x6", 12"x7" and 12"x8".

Estimating Quantities of Roofing Slate.—Obtain the net area of the roof in sq. ft. as described at the beginning of this chapter. Add 6″ to rafter length to allow for waste of normal roof.

Deduct one-half the area of chimneys and dormers if over 20 sq. ft. and less than 80 sq. ft. Make no deductions if less than 20 sq. ft. and deduct 20 sq. ft. less than actual area if more than 80 sq. ft.

Include area of dormer sides, sides of dormers if slated, slate saddles or other places where slate is used in addition to the main roof area. Include overhanging parts of dormers, etc.

Add 1 sq. ft. for each lin. ft. of hips and valleys, for loss in cutting and fitting.

Allow 2 to 15 percent additional slate, depending upon the extent to which the roof is intersected by other roofs, dormers, walls, etc.

Divide the total of the above by 100, which will give the number of "squares" of roofing required.

Slate is always sold at the quarry on the basis of the quantity required to cover 100 sq. ft. or a "square" of roof when slate is laid with a 3″ head lap. If the roof is flat or other than 3″ lap is used, the quantity must be corrected to the equivalent amount required as though the 3″ lap were used.

Items to Be Included in an Estimate for Slate Roofing.—The following items should be included to make a complete and accurate estimate on slate roofing:

1. Cost of slate (punched) on cars or trucks at the quarry.
2. Freight or trucking from quarry to destination.
3. Unloading from cars and hauling to job, also unloading and piling at job, unless delivered to the job by truck.

Trucking from quarry direct to job within a radius of 500 miles is now general practice in the Vermont-New York slate district.

4. Placing on roof and laying, (a) roofing felt, (b) elastic cement, (c) nails, (d) snow guards or snow rails, (e) sheet metal, (f) labor, including compensation insurance, Social Security taxes, (g) waste in handling, cutting and fitting.
5. Contractor's overhead expense, surety bond, if required, and profit on the work.

Size of Slate.—The following table gives the different sizes in which roofing slate is furnished, number required per square when laid with 3″ lap, and number of nails required per square based on 2 nails to each piece of slate.

Size of Slate Inches	Number per Square	Number of Nails Reqd. per Square	Size of Slate Inches	Number per Square	Number of Nails Reqd. per Square
10x 6	686	1,372	16x12	185	370
10x 7	588	1,176	16x14	159	318
10x 8	515	1,030	18x 9	213	426
10x10	414	828	18x10	192	384
12x 6	533	1,066	18x11	175	350
12x 7	457	914	18x12	160	320
12x 8	400	800	18x14	137	274
12x 9	355	710	20x10	169	338
12x10	320	640	20x11	154	308
12x12	267	534	20x12	141	282
14x 7	374	748	20x14	121	242
14x 8	327	654	20x16	106	212
14x 9	290	580	22x11	138	276
14x10	261	522	22x12	126	252
14x12	218	436	22x14	109	218
14x14	188	376	22x16	95	190
16x 8	277	554	24x12	115	230
16x 9	246	492	24x14	98	196
16x10	221	442	24x16	86	172

Slate $\frac{3}{4}$" and thicker and 24" or over in length should have 4 nail holes.

Weight of Slate Roofing.—A square of slate roofing, i. e., sufficient slate to cover 100 sq. ft. of roof surface with a standard 3" lap, will vary from 650 to 8,000 lbs. for thicknesses from the commercial standard $\frac{3}{16}$" to 2".

The weight of slate varies with the size of the slate, color and quarry and even sometimes in the same quarry. The variation may be from 10% above to 15% below the weights given in the following table:

Average Weight of Slate per Square (100 sq. ft.)

	Slate Thickness in Inches	Sloping Roof Allowing for 3" Lap	Flat Roof Without Lap
Standard	$\frac{3}{16}$	700	240
Selected full	$\frac{3}{16}$	750	250
	$\frac{1}{4}$	900	335
	$\frac{3}{8}$	1,400	500
	$\frac{1}{2}$	1,800	675
	$\frac{3}{4}$	2,700	1,000
	1	4,000	1,330
	$1\frac{1}{4}$	5,000	1,670
	$1\frac{1}{2}$	6,000	2,000
	$1\frac{3}{4}$	7,000	
	2	8,000	

Nails Required for Slate Roofing.—The quantity of nails required for slate roofing will vary with size, kind, etc., but the following table gives quantities of those commonly used:

Length in Inches	Approximate Number of Nails to the Pound "Copperweld" Slating Nails	Copper Wire Slat. Nails	Cut Copper Slat. Nails	Cut Brass Nails	Cut Yellow-Metal Slat. Nails
1	386	270	...	...	...
1¼	211	144	190	164	154
1½	176	134	135	140	140
1¾	133	112	100	108	...
2	87	104	...	88	...
2¼	...	46	...	80	...
2½	...	...	...	64	...
2¾	...	...	...	52	...
3	...	...	...	48	...

Labor Punching Slate.—Because of high labor costs on the job, it is much cheaper to have slate punched at the quarry. The labor cost of punching slate on the job will vary with the size of the slate, as the larger the slate the fewer pieces required per square.

If one slater is working on the job with a helper, the helper should punch the slate and carry them to the slater as fast as required. In instances of this kind, there should be no additional charge for punching. If, however, there is only one man working on the job, who must punch the slate and lay them, a man should punch one square of slate in 30 to 40 min. or 12 to 16 sqs. per 8-hr. day, at the following cost per 100 sq. ft. (sq.):

	Hours	Rate	Total	Rate	Total
Slater	0.6	$.....	$.....	$7.00	$4.20

Labor Cost of Laying Roofing Slate.—The labor cost of laying roofing slate will vary considerably with the size of the slate, thickness, type of roofs, etc., but when large thick slate are used for graduated roofs, the labor costs will run higher than when the same size slate are used on standard roofs.

The size of slate best adapted for plain roofs are large, wide slates, such as 16"x12", 18"x12", 20"x12" or 24"x12". Slate from 16"x8" to 20"x10" are also popular sizes. For roofs cut up into small sections, the 14"x7" and 16"x8" are very popular.

A roofing crew consisting of two slaters and one helper can work to advantage and perform the work more economically than one man working alone. In some localities the helper is considered an apprentice and is permitted to lay slate, in others he can only punch and carry the slate to the slaters.

Laying 16"x8" Roofing Slate.—When working on plain roofs that do not require much cutting, 2 slaters and a helper should lay felt, handle and lay 350 to 450 sq. ft. (3½ to 4½ sqs.) of 16"x8" slate per 8-hr. day. On more complicated hip or gable roofs, requiring considerable cutting and fitting for hips, valleys, dormers, etc., 2 slaters and a helper should handle and lay 175 to 225 sq. ft. (1¾ to 2¼ sqs.) of 16"x8" slate per 8-hr. day.

Laying 18"x9" Roofing Slate.—When laying 18"x9" slate on plain roofs, 2 slaters and a helper should lay felt, handle and lay 400 to 500 sq. ft. (4 to 5 sqs.) per 8-hr day.

On more complicated hip or gable roofs, requiring considerable cutting and fitting for hips, valleys, dormers, etc., 2 slaters and a helper should lay 250 to 300 sq. ft. (2½ to 3 sqs.) per 8-hr. day.

Laying 20"x10" Roofing Slate.—When laying 20"x10" slate on plain roofs, 2 slaters and a helper should lay felt, handle and lay 500 to 600 sq. ft. (5 to 6 sqs.) of roof per 8-hr. day, but on more complicated roofs, requiring considerable cutting and fitting for hips, valleys, dormers, etc., the same crew would lay only 300 to 350 sq. ft. (3 to 3½ sqs.) per 8-hr. day.

Laying 22"x12" Roofing Slate.—On straight roofs, 2 slaters and a helper should lay felt, handle and lay 550 to 650 sq. ft. (5½ to 6½ sqs.) of 22"x12" slate per 8-hr. day, but on the more complicated roofs, requiring cutting and fitting for hips, valleys, dormers, etc., the same crew would lay only 350 to 400 sq. ft. (3½ to 4 sqs.) per 8-hr. day.

Laying Graduated Roofing Slate.—When laying graduated roofing slate from 3/16" to ¾" thick and 12" to 24" long, considerable care is required in selecting the right slate for each course and laying them to obtain the desired effect. On work of this kind 2 slaters and a helper should lay felt, handle and lay 150 to 200 sq. ft. (1½ to 2 sqs.) of roof per 8-hr. day.

Cost of 100 Sq. Ft. (1 Sq.) 16"x8" Standard Slate Roofing

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 sat. felt..		$.....	$.....	$2.40	$ 2.40
1 sq. 16"x8" slate.....		.....	.....	50.00	50.00
Trucking, 700 lbs.....		.....	.....	1.25	8.75
3 lbs. 1¼" copper nails....		.....	.....	1.25	3.75
Slater	4	.....	.....	7.00	28.00
Helper	2	.....	.....	5.00	10.00
Cost per 100 sq. ft.	6		$.....		$102.90

For complicated hip or gable roofs, double the time given above. When work is sublet, add 25 to 30% roofing contractor's overhead expense and 10% profit.

Cost of 100 Sq. Ft. (1 Sq.) 18"x9" Standard Roofing Slate

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 sat. felt..		$.....	$.....	$2.40	$ 2.40
1 sq. 18"x9" slate.....		.....	.....	50.00	50.00
Trucking, 700 lbs.....		.....	.....	1.25*	8.75
2.5 lbs. 1¼" copper nails...		.....	.....	1.25	3.13
Slater	3.50	.....	.....	7.00	24.50
Helper	1.75	.....	.....	5.00	8.75
Cost per 100 sq. ft.....	5.25		$.....		$97.53

For complicated hip or gable roofs, add 2.5-hrs. slater and 1.25-hrs. helper time. When work is sublet, add 25 to 30% roofing contractor's overhead expense and 10% profit.

Cost of 100 Sq. Ft. (1 Sq.) 20"x10" Standard Roofing Slate

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 sat. felt..		$.....	$.....	$2.40	$ 2.40
1 sq. 20"x10" slate.....		.....	.....	50.00	50.00
Trucking, 700 lbs.....		.....	.....	1.25*	8.75
2 lbs. 1¼" copper nails....		.....	.....	1.25	2.50
Slater	3.0	.....	.....	7.00	21.00
Helper	1.5	.....	.....	5.00	7.50
Cost per 100 sq. ft.....	4.5		$.....		$92.15

For complicated hip or gable roofs, add 2-hrs. slater and 1-hr. helper time. When work is sublet, add 25 to 30% roofing contractor's overhead expense and 10% profit.

Cost of 100 Sq. Ft. (1 Sq.) 22"x12" Standard Roofing Slate

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 sat. felt..		$.....	$.....	$2.40	$ 2.40
1 sq. 22"x12" slate.....		.....	.....	50.00	50.00
Trucking, 700 lbs.....		.....	.....	1.25*	8.75
1.5 lbs. 1¼" copper nails...		.....	.....	1.25	1.88
Slater	2.6	.....	.....	7.00	18.20
Helper	1.3	.....	.....	5.00	6.50
Cost per 100 sq. ft.....	3.9		$.....		$87.73

For complicated hip or gable roofs, add 1.6-hrs. slater and 0.8-hr. helper time. When work is sublet, add 25 to 30% roofing contractor's overhead expense and 10% profit.

*Varies according to locality.

Cost of 100 Sq. Ft. (1 Sq.) Rough Texture Slate Roof Random Widths and $\frac{3}{16}$" to $\frac{1}{2}$" Thick

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 sat. felt..		$.....	$.....	$2.40	$ 2.40
1 sq. rough texture slate..		.....	.....	63.00	63.00
Trucking, 900 lbs.		.....	.....	1.25*	11.25
3 lbs. $1\frac{3}{4}$" copper nails....		.....	.....	1.25	3.75
Slater	7.50	.....	.....	7.00	52.50
Helper	3.75	.....	.....	5.00	18.75
Cost per 100 sq. ft.....	11.25		$.....		$151.65

Cost of 100 Sq. Ft. (1 Sq.) Graduated Slate Roof, Slate 12" to 24" Long and $\frac{3}{16}$" to $\frac{3}{4}$" Thick

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 sat. felt..		$.....	$.....	$2.40	$ 2.40
1 sq. grad. slate, $\frac{3}{16}$" to $\frac{3}{4}$"		.....	.....	90.00	93.00
Trucking, 2,000 lbs.....		.....	.....	1.25*	25.00
4 lbs. $1\frac{3}{4}$" copper nails....		.....	.....	1.25	5.00
Slater	9.0	.....	.....	7.00	63.00
Helper	4.5	.....	.....	5.00	22.50
Cost per 100 sq. ft.....	13.5		$.....		$210.90

When work is sublet, add 25 to 30% roofing contractor's overhead expense and 10% profit.

Prices on Slate Roofing

The following prices are in effect on roofing slate in car lots, f. o. b. cars at the quarry, Pennsylvania.

A minimum car of standard No. 1 slate is 60 sqs. Maximum car 120 sqs.

Less than carload shipments usually require crating, costing $10.00 per square, depending upon the cost of lumber, with possible trucking charges at shipping point.

Prices on Genuine Bangor Certificate Roofing Slate, Bangor, Pa.

Prices are for sufficient slate to cover 100 sq. ft. of roof, using a 3" head lap. Prices do not include punching for nail holes. If slate are shipped punched, add $2.00 per square.

Graduated Slate, Random Widths

No. 1 Clear Smooth or Rough Texture	Price per Square	Estimated Weight, Lbs.
$\frac{1}{4}$" thick	$ 50.00	1,000
$\frac{3}{8}$" thick	62.00	1,500
$\frac{1}{2}$" thick	78.00	2,000
$\frac{5}{8}$" thick	97.00	2,500
$\frac{3}{4}$" thick	115.00	3,000

*Varies according to locality.

Approximate Prices on Vermont Roofing Slate

Standard commercial thickness 3/16". In lengths as indicated and standard widths. Extra charge of $1.00 per square for punching standard and rough texture sea green and dark mottled green. Prices on all other colors and grades include punching.

All prices are for sufficient slate to cover 100 sq. ft. of roof, using a 3" head lap.

	Approx. Weight	Length of Slate, Inches 24"-16" x Random Widths	14 x Random Widths	12 x Random Widths
Semi-Weathering Green and Gray				
Standard Thickness 3/16"-1/4"	800 lbs.	$43.00	$42.00	$38.00
Rough Texture 3/16"-3/8"	900 lbs.	43.00	42.00	38.00
Variegated Purple				
Standard Thickness 3/16"-1/4"	800 lbs.	60.00	59.00	55.00
Rough Texture 3/16"-3/8"	900 lbs.	60.00	59.00	55.00
Vermont Black & Gray-Black				
Rough Texture 3/16"-3/8"	900 lbs.	55.00	54.00	50.00
Unfading Mottled Gray Green and Mottled Gray Black				
Standard Thickness 3/16"-1/4"	800 lbs.	60.00	59.00	55.00
Rough Texture 3/16"-3/8"	900 lbs.	60.00	59.00	55.00
Unfading Mottled Green and Purple				
Standard Thickness 3/16"-1/4"	800 lbs.	60.00	59.00	55.00
Rough Texture 3/16"-3/8"	900 lbs.	60.00	59.00	55.00
Unfading Green				
Standard Thickness 3/16"-1/4"	800 lbs.	60.00	59.00	55.00
Rough Texture 3/16"-3/8"	900 lbs.	60.00	59.00	55.00

Prices on Architectural Slate

Random lengths and widths or one length and random widths. Price includes nail holes. No allowance if furnished without holes.

The following prices are approximate only. Check with quarry or mill before quoting.

Kind of Slate	Thickness of Slate in Inches Per Square F.O.B. Quarry Prices 1/4"	3/8"	1/2"	3/4"
Semi-Weathering Green & Gray	$50.00	$55.00	$60.00	$88.00
Variegated Purple	64.00	83.00	111.00	150.00
Vermont Black & Gray Black	61.00	72.00	88.00	99.00
Unfading Mottled Gray-Green	64.00	83.00	111.00	150.00
Mottled Gray-Black	61.00	72.00	88.00	99.00
Unfading Mottled Green & Purple	64.00	83.00	111.00	150.00
Unfading Green	64.00	83.00	111.00	150.00
Approximate Weight	900 lbs.	1300 lbs.	1800 lbs.	2500 lbs.

CLAY ROOFING TILE

The following information on clay roofing tile has been furnished through the courtesy of the Ludowici-Celadon Company, Chicago, Illinois.

When estimating the quantities of clay roofing tile, the roof areas are obtained in the same manner as described at the beginning of this chapter.

After the total number of sq. ft. of surface has been obtained, add about 3 per cent to the net measurement to take care of cutting and waste.

Also obtain the number of lin. ft. or pieces of special tile required, such as ridges, hips, hip starters, hip terminals, finials, etc., as it will be necessary to have the exact quantities of these fittings when ordering.

Hip and valley fittings should be figured by the lineal foot. Closure and finishing pieces, such as hip starters, closed ridge ends, terminals, etc., should be figured by the piece.

Where interlocking shingle tiles are used, detached gable rake pieces are required for all gable roofs not intersecting with vertical surfaces. These pieces are measured by the total lineal feet of gable rake, keeping separate quantities for lefts and rights as determined by facing roof eave.

For all shingle tile roofs, end bands or half-tile are required on each course, alternating from one end to the other to break joints. End bands are figured by the lineal feet of gable rake, taking half the length at each gable rake.

Laying Interlocking Shingle Tile. On a roof of average difficulty, a crew consisting of 2 roofers, and an apprentice or helper should handle and lay 500 to 600 sq. ft. of interlocking shingle tile per 8 hr day, at the following labor cost per 100 sq. ft. (1 sq.):

	Hours	Rate	Total	Rate	Total
Roofer	3.0	$.....	$.....	$7.00	$21.00
Helper	1.5	.....	.....	5.00	7.50
Cost per 100 sq. ft.	4.5		$.....		$28.50

On steep or cut up roofs, add 15 to 25 percent. For roofs over 3 stories high to eaves, add 1.5 hrs. helper time.

Laying Tile Shingles (Architectural Patterns.) On a roof of average difficulty, 2 roofers and a helper should handle and lay 325 to 375 sq. ft. of tile shingles per 8-hr. day, at the following labor cost per 100 sq. ft. (1 sq.):

	Hours	Rate	Total	Rate	Total
Roofer	4.6	$.....	$.....	$7.00	$32.20
Helper	2.3			5.00	11.50
Cost per 100 sq. ft.	6.9		$.....		$43.70

On steep or cut-up roofs, add 15 to 25 percent. For roofs over 3 stories high to eaves, add 2.3-hrs. helper time.

Laying Miscellaneous Tile Pattern Roofs.—Where Spanish or French pattern tile is used on new work, figure same labor costs as for interlocking shingle tile.

Labor laying Mission tile will vary according to size and exposure of units. On new work of average difficulty, using 15"x8" tile with 12" exposure, 2 roofers and a helper should handle and lay 350 to 400 sq. ft. per 8-hr. day.

Items to Be Included When Estimating Tile Roofs.—The following items should be included when estimating the cost of a clay shingle tile roof.

One roll coated felt or roll roofing weighing 40 lbs. per sq.

3-lbs. roofing nails, 1¾" long.

Allow 1-lb. colored elastic cement for pointing joints for each 20 lin. ft. of hips and ridges.

Freight on Roofing Tile.—Freight on roofing tile is a variable item, depending upon the weight of the tile, distance of job from factory, etc., and may vary from $8.00 to $15.00 or more per square. To most midwest destinations, freight will average about $8.00 per sq. Add $1.00 per square loading charge. Always obtain definite freight rates if possible.

Trucking from Cars to Job Site.—Most tile roofing shipments are made by truck. However, where shipment is by rail, figure $5.00 to $6.00 per square for unloading cars and hauling to job site.

Roofing Contractor's Overhead Expense and Profit.—In addition to the actual cost of the roof, it will be necessary to add for the roofing contractor's overhead expense and profit, consisting of workmen's compensation and public liability insurance, social security and unemployment compensation taxes, plus the roofing contractor's expense of doing business and profit. This may vary from 40% to 50% of the actual cost of the work, depending upon the size of the job and the desirability of the work.

Clay Roofing Tile.—Clay roofing tile are manufactured in a variety of patterns, styles, sizes, colors and finishes, which vary in cost depending upon color, finish and whether machine or handmade.

For present contemporary designs, the most popular pattern is the interlocking shingle tile, a lightweight unit available in several sizes, colors and surface textures.

Tile shingles (architectural patterns) are also in current use for new work and are available in various sizes, colors and surface finishes.

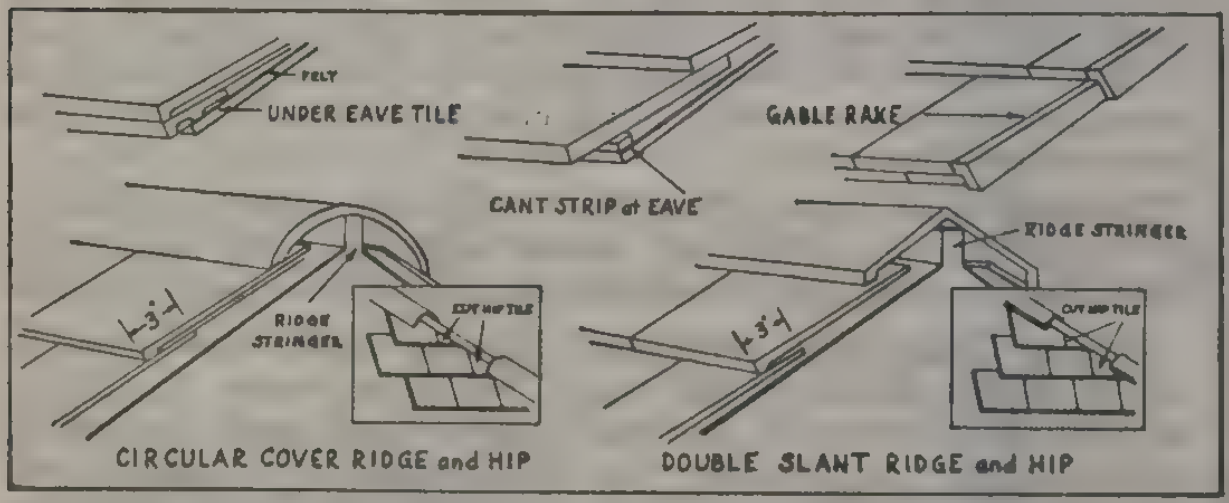
Other tile patterns, such as Spanish, French, Mission, etc., are less frequently used, but are available in several styles, sizes and colors for new work, and may also be obtained, to match existing roof tile for additions and repair work, on special order.

Estimating Data on Interlocking Shingle Tile

Description	Size Inches	Exposure Inches	No. Tile Req'd. 100 Sq. Ft. Roof	Weight Per 100 Sq. Ft.
Designer	9x14	8¼x11	160	800 lbs.

The above interlocking statistics also apply to Williamsburg, Early American and Tile Stones surfaces.

Designer tile are available with a smooth or weathered surface. Standard colors for smooth surface; red, buff, coral, green, gray green and white. Colors for weathered surface; red, brown,



Details of Clay Interlocking Shingle Tile Roofing

black and green. Early American tile have a rugged grained surface. Standard colors are grays and greens. Williamsburg tile have a rough combed surface. Standard colors are grays and greens. Tile stones have a stone-like surface. Standard colors are grays and greens.

Estimating Data on Tile Shingles (Architectural Patterns)

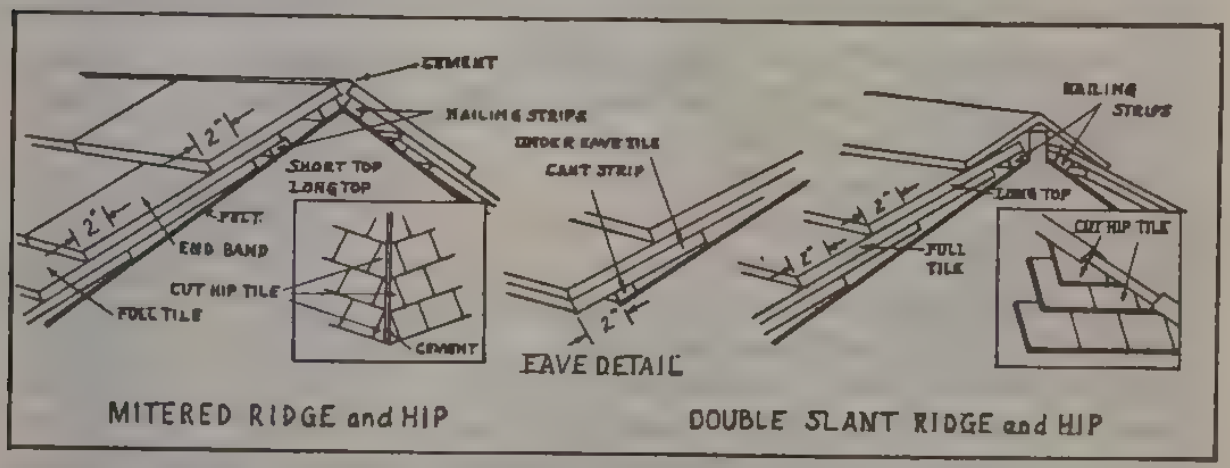
Description	Size Inches	Exposure Inches	No. Tile Req'd. 100 Sq. Ft. Roof	Weight Per 100 Sq. Ft.
Provincial	7½x15	7½x6½	295	1,500 lbs.
Georgian	5x15	5x6½	443	1,550 lbs.
Georgian	7x15	7x6½	317	1,550 lbs.
Georgian	8x15	8x6½	277	1,550 lbs.
Colonial	7x15	7x6½	317	1,700 lbs.
Norman	7x12	7x5	412	1,650 lbs.
Norman	7x15	7x6½	317	1,650 lbs.

Provincial tile are available with a fine scored or weathered surface. Standard colors are blacks, browns, greens and reds.

Georgian tile have a rough combed surface. Standard colors are grays and greens.

Colonial tile have a rugged grained texture. Standard colors are grays and greens.

Norman tile have a pitted and weathered surface. Standard colors are greens, grays, browns and blacks.



Details of Clay Tile Shingle Roofing

Approximate Prices of Interlocking Shingle Tile

Prices are for designer style, f.o.b. factory. Add 30 percent for Williamsburg and tile stones and 20 percent for Early American, to color prices.

Field Tile	Price per Square
Smooth texture; red	$38.00
Smooth texture; buff, coral, green and gray	45.00
Smooth texture; white	49.00
Weathered texture; red	40.00
Weathered texture; brown and black	41.00
Weathered texture; green	46.00

Approximate Prices of Interlocking Shingle Tile—Continued

Cut Work, per lin. ft., one side only	Smooth Red	Standard Colors
Cut hip	$0.65	$0.80
Chamfered cut hip	1.00	1.20
Cut valley	.65	.80
Short course tile	.52	.68

Above prices are for field tile factory cut to fit at hips, valleys or ridges. Two lineal feet of cut tile are required for each lineal foot of hip, valley or ridge. Specify slope of roof and proportion of rights and lefts.

Eave and Gable Fittings, per lin. ft.	Smooth Red	Standard Colors
Under Eave	$0.23	$0.30
Gable Rake	.46	.60
End Band	.23	.35
Barge tile, full size	.29	.34
Barge tile, half size	.29	.34

For barge tile colored on bottom of projection at gable, add 10 cts. per lineal foot. Specify proportion of rights and lefts.

Hip and Ridge Fittings	Smooth Red	Standard Colors
Circular Cover for hip or ridge, lin. ft.	$0.23	$0.30
Circular Cover Closed Ridge Ends, piece	4.60	5.60
Circular Cover Hip Starters, per piece	2.40	3.10
Double Slant Ridge, per lin. ft.	.50	.65
Double Slant Closed Ends, per piece	.85	1.10
Double Slant Hip Starters, per piece	.75	1.00
Double Slant Angle Fittings, per piece	4.60	5.75
Double Slant Ridge Tees, per piece	5.75	8.05
Double Slant 3-Way Terminals, per piece	9.50	12.00
Double Slant 4-Way Hip Finials, per piece	26.00	35.00

Specify slope of roof. If slope is greater than 12" in 12", double above fitting prices *for all hip and ridge rolls.*

Approximate Prices of Tile Shingles (Architectural Patterns)

Prices per square sufficient to cover 100 sq. ft. of roof, f.o.b. factory.

Style	Red	Black or Brown	Gray or Green
Provincial	$67.00	$ 69.00	$ 75.00
Georgian			92.00
Colonial			105.00
Norman		150.00	150.00

Use same fittings listed for interlocking shingle tile, if required.

Prices for Miscellaneous Tile Patterns.—Prices for tile patterns, such as Spanish, French, Mission, etc., vary considerably depending upon patterns, size, color and finish. Prices range from $70.00 per square for an ordinary Spanish pattern, with smooth red finish, to $160.00 per square or more for a special mission pattern with hand treated finish.

When estimating clay tile roof work, always obtain manufacturer's quotation covering full job requirements before submitting bid.

Cost of 100 Sq. Ft. Clay Interlocking Shingle Tile Roofing

	Hours	Rate	Total	Rate	Total
1 Sq. roll No. 40 Felt.....		$.....	$.....	$2.40	$ 2.40
103 S.F.Interlocking Tile.		.....	.....	40.00	40.00
Misc. Tile, Color, etc. ...		.....	.....	7.50	7.50
Freight or trucking, 800 lbs.....		.....	.....	1.25*	10.00
2 lbs. nails.....		.....	.....	1.25	2.50
Roofer	3.0	.....	.....	7.00	21.00
Helper	1.5	.....	.....	5.00	7.50
Cost per 100 sq. ft.	4.5		$.....		$90.90

Cost of 100 Sq. Ft. (1 Sq.) Clay Tile Shingle Roofing

	Hours	Rate	Total	Rate	Total
1 Sq. roll No. 40 Felt.....		$.....	$.....	$2.40	$ 2.40
100 Sq. Ft. Tile Shingles..		.....	.....	69.00	69.00
Misc. tile, color, etc.....		.....	.....	12.50	12.50
Freight or trucking 1,500 lbs.		.....	.....	1.25*	18.75
4 lbs. nails		.....	.....	1.25	5.00
Roofer	4.6	.....	.....	7.00	32.20
Helper	2.3	.....	.....	5.00	11.50
Cost per 100 sq. ft.	6.9		$.....		$151.35

ASBESTOS SHINGLES

Asbestos shingles are made of asbestos fiber and portland cement, united under hydraulic pressure and cut to shingle shapes. They are furnished in a variety of sizes, shapes and colors, so the cost will depend upon the style and color of shingles used, method of laying and size and shape of the roof.

When estimating quantities of asbestos shingles, the measurements are taken in the same manner as for shingle or slate roofs. The length of the eaves must be measured to obtain the number of lin. ft. of starters required, also the length of the hips and ridges, as either shingles or a special ridge roll will be required. Asbestos shingles are sold by the square

*Varies according to locality.

containing sufficient shingles to cover 100 sq. ft. of surface.

They are made in hexagonal and Scotch or Dutch Lap styles, individual shingles, and American Colonial, Colorbestos slates and American Method strip shingles, among others, which are described on the following pages.

Preparation of Roof.—Asbestos shingles are for use on pitched roofs only. For American Method shingles the minimum allowable slope of roof is 4″ per foot; for the hexagonal and Dutch Lap Method shingles, 5″ per foot. A slope of 3″ per foot is permissible with adequate underlayment procedure.

The roofing boards should be well seasoned, of narrow width and laid in the usual manner breaking joints and nailing securely in place with at least two nails at each rafter or purlin, leaving no loose ends. Exterior grade plywood may be used for sheathing. A cant for the eaves shingles should be provided by the projection of the cornice molding ¼″ above the roof boarding or by a lath (¼″x1½″) nailed parallel and flush with lower edge of roof boarding. Over the roof boarding lay one thickness of 15-lb. or heavier, asbestos roofing felt, laying horizontally with a 4″ lap and with a 12″ lap on hips, ridges and valleys. Ridge shingles should be laid in the direction away from prevailing winds.

Method of Laying Asbestos Shingles

American Method Asbestos Shingles.—When laying American Method individual shingles, apply over the roofing felt, one course of starter (9″x16″) shingles at eaves lengthwise and parallel with same, overhanging the eaves about 1″. Apply the second course, using main body shingles, entirely covering the first course as shown in the accompanying illustration, breaking joints, after which proceed in the regular manner as with wooden shingles or slate, exposing 7″ to the weather, with a minimum headlap of 2″. Fasten each shingle in place with at least 2 galvanized iron or copper needle pointed shingle nails. Never drive nails down tight as it is only necessary to drive them firmly. Over the ridges and hips apply asbestos hip and ridge shingles 4¾″ to 5⅝″ wide by 14″ long.

All chimneys, valleys, etc., should be flashed with copper or other approved material.

American Method shingles are 8″x16″ in size, ¼″ thick, and require about 260 shingles per square, or 16x16 in size, ¼″ thick and requires 130 shingles per square.

For new work figure 3 lbs. 1½″ nails, and for re-roofing figure 4 lbs. 2″ galvanized nails per square.

Hexagonal Method Asbestos Shingles.—The Hexagonal or "Honeycomb" Method of applying asbestos shingles apparently

shows 6 sides of the shingle, thus overcoming the objections to severely straight lines and producing a pleasing effect.

Apply one course of starter (4"x16") shingles end to end, parallel with and overhanging the eaves 1", over which apply one course of half shingles, entirely covering the starter and breaking all joints as shown in the accompanying illustration.

Cover balance of roof with body shingles 16"x16", laid as shown, exposing 13"x13" to the weather. Securely fasten all shingles in place with galvanized or copper needle pointed nails, and fasten the points of the main body shingles with special copper storm nails. Never drive nails down tight as it is only necessary to drive them firmly. All the main body shingles should be laid with the diagonal lines on a 45-degree angle with the eaves. Over the ridges and hips apply asbestos ridge and hip rolls, with not less than 3" lap, fastening in place with special roll fasteners furnished for the purpose.

Scotch or Dutch Lap Method of Laying Asbestos Shingles.—The Scotch or Dutch Lap Method of applying asbestos shingles closely resembles the American Method in appearance yet approximates the cost of the Hexagonal Method.

Apply over the felt at eaves, one course of eave starter shingles (4"x16") parallel with and overhanging eaves 1", with each shingle overlapping preceding shingle approximately $\frac{1}{3}$ its length so that nail holes will occur one over the other. Cut the first starter to $\frac{2}{3}$ its original length and with a new hole punched $2\frac{13}{16}$" from the cut end, apply at the end of the roof to overhang the gable 1". Fasten with a nail through the new hole. Then apply a full length starter to overlap the first starter one-half its length. Fasten both with a nail through coinciding holes. Proceed in a similar manner to end of roof.

Completely cover starters and balance of roof with body shingles (16"x16") laid as shown, exposing $10\frac{2}{3}$"x13" to the weather, securing each shingle with 2 shingle nails and 1 storm anchor. The shingles are aligned on nail and storm anchor holes and therefore automatically establish a one-third side lap and 3" head lap. If the shingles are laid with one-quarter side lap, 12"x13" is exposed. Ridges, hips and exterior corners are finished with asbestos ridge and hip shingles or asbestos ridge roll in the same manner as with other types of asbestos shingles.

Data on Scotch or Dutch Lap Method Asbestos Shingles

		Laid with 4" or ¼" Side Lap			Laid with 5½" or ⅓" Side Lap		
Size	Thickness Inches	Expos.	No. per Sq.	Wt. per Sq.	Expos.	No. per Sq.	Wt. per Sq.
16"x16"	$\frac{5}{32}$"	12"x13"	92	265 lbs.	$10\frac{2}{3}$"x13"	104	300 lbs.

When laid with 4" or ¼ side-lap, it requires (184) 0.8-lb. of 1¼" needlepoint nails and 92 storm buttons per square.

When laid with 5⅓" or ⅓ side-lap, it requires 104 shingles, (216) 1 lb. of 1¼" needlepoint nails and 104 storm buttons per square.

Starter shingles for the above may be 4"x16" laid lengthwise. Approximate price $3.50 per 100 lin. ft.

Data on Hexagonal Method Asbestos Shingles

Size	Thickness Inches	Expos. Inches	No. Shingles per Sq.	Wt. Lbs. per Sq.	Nails Reqd. Lgth.	Nails Reqd. Lbs.
16"x16"	5/32"	13"x13"	86	240	1¼"	1*

*Also requires 86 storm anchors per square.

Requires 172 needlepoint nails and 86 storm buttons per square.

Starter shingles for above may be 4"x16" laid lengthwise. Cost about $3.50 per 100 lin. ft.

Eaves shingle for use with hexagonal shingles 21" long. Requires 58 pcs. per 100 lin. ft. Price $15.00 per 100 lin. ft.

J-M * American Colonial Asbestos Strip Shingles.—An asbestos strip shingle 14"x30" in size, 5/32" thick and laid with an exposure of 6". They are cedar grained to resemble wood shingles and have staggered butt lines to represent five individual shingles.

It requires 80 full size shingles per square, and 1¾ lbs. of 1¼" galvanized needle-point nails (approx. 230 to the lb.) on new work and 2½ lbs. (approx. 150 to the lb.) of 2" nails when applied over old roofs. Shingles are packed in bundles of 16.

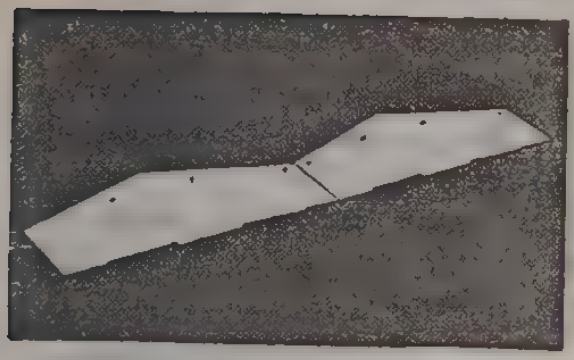
Supplementary shingles used are starter and hip and ridge shingles. Four nails are required in each shingle. Minimum allowable roof pitch is 3" per foot with the double underlayment treatment. For Class A label 4" pitch per foot or greater, with recommended underlayment is required.

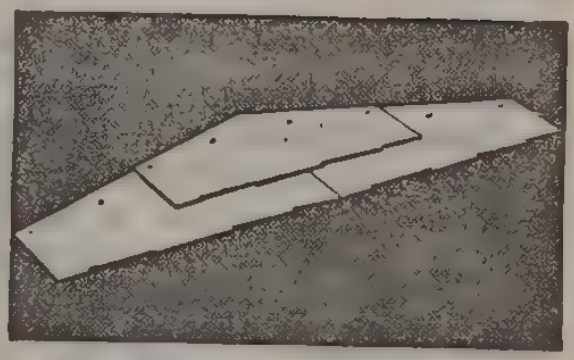
Furnished in flint grey, slate black, weathered green, brown and shell white. The price of these shingles is approximately $19.00 per square.

Starter shingles for above are 30"x8" laid lengthwise. Price about $9.30 per 100 lin. ft.

Hip and ridge shingles for use with American Colonial strip shingles are approximately 5"x14"x5/32" and when laid 7" exposed to the weather require 340 pcs. per 100 lin. ft. and cost about $18.75 per 100 lin. ft.

* Johns-Manville Sales Corp. Chicago, Ill.





Method of Starting American Colonial Asbestos Shingles.

Method of Laying American Colonial Asbestos Shingles.

J-M * Colorbestos Slates.—Colorbestos Slate Shingles may be applied to roofs having a minimum slope of 3" per foot with the proper underlayment. Slates are 9.35"x16" in size and are approximately $\frac{1}{4}$" thick. 220 shingles are required per square and they are laid with a 7" exposure and a minimum 2" headlap.

Slates come in London grey, Canterbury buff, Edinburgh black, Roman red, Normandy purple, and Inverness green. For starters use #51 Salem starters. Hip and ridge pieces are cut from slates on job.

Data on Ridge Roll

Curved ridge roll is 18" long, has a $2\frac{3}{8}$" radius. It requires 80 pcs. per 100 lin. ft. when laid with 15" exposed to the weather and requires $2\frac{1}{2}$ lbs. of 3" nails and 80 storm anchors per 100 lin. ft. Price about $60.00 per 100 lin. ft.

Approximate Prices of Asbestos Roofing Shingles

Kind of Shingle	Size	Thickness	Price per Square
Salem Roof Shingle	8"x16"	$\frac{1}{4}$"	$40.00
Hexagonal Method	16"x16"	$\frac{5}{32}$"	17.50
Dutch Lap Method	16"x16"	$\frac{5}{32}$"	17.80
American Colonial	14"x30"	$\frac{5}{32}$"	19.00
Colorbestos Slates	9.35"x16"	$\frac{1}{4}$"	45.00

* Johns-Manville Sales Corp. Chicago, Ill.

Laying Asbestos Shingles

The cost of laying asbestos shingles will vary with the size of the shingles, style in which they are laid, whether plain or complicated roofs, and upon the labor employed.

Where possible, it is economy to work a helper with two roofers, as the helper can handle all the shingles, carry them to the roof and perform all work around the job except the actual laying of the shingles.

However, if roofers do not work with helpers in your locality, figure total time given as roofer time.

Laying Salem Roof Shingles.—When laying 8"x16" individual asbestos shingles by the American method, 2 roofers and a helper should handle and lay 350 to 450 sq. ft. (3½ to 4½ sqs.) per 8-hr. day, on plain roofs. On more complicated hip or gable roofs, requiring considerable cutting and fitting for hips, valleys, dormers, etc., 2 roofers and a helper should handle and lay 225 to 275 sq. ft. (2¼ to 2¾ sqs.) of 8"x16" shingles per 8-hr. day.

Laying Asbestos Shingles by the Hexagonal Method.—When laying 16"x16" asbestos shingles by the hexagonal method on fairly plain roofs, a crew consisting of two roofers and one helper should handle and lay 600 to 700 sq. ft. (6 to 7 squares) per 8-hr. day.

On more complicated roofs, the labor cost will be higher due to the necessity of cutting and fitting shingles. This additional labor will vary, depending upon how badly the roof is broken up, but a crew consisting of two roofers and a helper should handle and lay 400 to 500 sq. ft. (4 to 5 sqs.) per 8-hr. day, unless very unusual conditions exist.

Laying Asbestos Shingles by the Dutch Lap Method.—When laying 16"x16" asbestos shingles by the Dutch Lap Method on either plain or complicated roofs, figure approximately 15% more than labor costs given for the Hexagonal Method.

Cost of 100 Sq. Ft. (1 Sq.) 8"x16" Salem Roof Shingles Laid on Plain Roofs

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt.....		$.....	$.....	$ 2.40	$ 2.40
1 sq. asbestos shingles....		.....	.....	40.00	40.00*
3 lbs. nails		.....	.....	.30	.90
Roofer	4	.....	.....	7.00	28.00
Helper	2	.....	.....	5.00	10.00
Cost per 100 sq. ft. ...	6		$.....		$81.30

*Shingle prices vary due to size, thickness, texture and color. Always obtain delivered prices in your locality before submitting bids. Also add for starter shingles, hips, ridges, etc.

If laid on a complicated or "cut-up" roof, add 2.5-hrs. roofer and 1.25-hrs. helper time per 100 sq. ft.

Cost of 100 Sq. Ft. (1 Sq.) 16"x16" Asbestos Shingles Laid Hexagonal Method on Plain Roofs

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt.....		$.....	$.....	$ 2.40	$ 2.40
1 sq. 16"x16" shingles....		.....	.....	17.50	17.50*
1 lb. nails		.....	.....	.30	.30
86 storm anchors.....		.....	.....	.006	.52
Roofer	2.4	.....	.....	7.00	16.80
Helper	1.2	.....	.....	5.00	6.00
Cost per 100 sq. ft.	3.6		$.....		$43.52†

If laid on a complicated or "cut-up" roof, add 1.2-hrs. roofer and 0.6-hr. helper time per 100 sq. ft.

Add for starters, eaves starters and hip and ridge shingles.

Cost of 100 Sq. Ft. (1 Sq.) 16"x16" Asbestos Shingles Laid Dutch Lap Method with 4" or $\frac{1}{4}$ Side Lap on Plain Roofs

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt.....		$.....	$.....	$ 2.40	$ 2.40
1 sq. 16"x16" shingles....		.....	.....	17.80	17.80
1 lb. nails.....		.....	.....	.30	.30
92 storm anchors.....		.....	.....	.006	.55
Roofer	2.8	.....	.....	7.00	19.60
Helper	1.4	.....	.....	5.00	7.00
Cost per 100 sq. ft.....	4.2		$.....		$47.65†

If laid on a complicated or "cut-up" roof, add 1.4-hrs. roofer and 0.7-hr. helper time per 100 sq. ft.

Add for starters and hip and ridge shingles.

Cost of 100 Sq. Ft. (1 Sq.) 16"x16" Asbestos Shingles Laid Dutch Lap Method with 5$\frac{1}{3}$" or $\frac{1}{3}$ Side Lap on Plain Roofs

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt.....		$.....	$.....	$ 2.40	$ 2.40
1.13 sqs. 16"x16" shingles		.....	.....	17.80	17.80*
1 lb. nails		.....	.....	.30	.30
104 storm anchors		.....	.....	.006	.62
Roofer	3.2	.....	.....	7.00	21.40
Helper	1.6	.....	.....	5.00	8.00
Cost per 100 sq. ft.	4.8		$.....		$50.52†

If laid on a complicated or "cut-up" roof, add 1.6-hrs. roofer and 0.8-hr. helper time per 100 sq. ft.

*Shingle prices vary due to size, thickness, texture and color. Always obtain delivered prices in your locality before submitting bids. Also add for starter shingles, hips, ridges, etc.

†If roofing is sublet, add for roofing contractor's overhead expense and profit, which may vary from 30 to 40 percent.

Cost of 100 Sq. Ft. (1 Sq.) 12"x24" Colorbestos Slate Shingles Laid on Plain Roofs

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt.....		$.....	$.....	$ 2.40	$ 2.40
1 sq. Colorbestos Slates...		.....	.....	45.00	45.00*
1 lb. nails		.....	.....	.30	.30
80 storm anchors		.....	.....	.006	.48
Roofer	3.8	.....	.....	7.00	26.60
Helper	1.9	.....	.....	5.00	9.50
Cost per 100 sq. ft.	5.7		$.....		$84.28†

If laid on a complicated or "cut-up" roof, add 1-hr. roofer and 0.5-hr. helper time per 100 sq. ft.

Add for starters and hip and ridge shingles.

Cost of 100 Sq. Ft. (1 Sq.) 14"x30" American Colonial Asbestos Strip Shingles Laid on Plain Roofs

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt.....		$.....	$.....	$ 2.40	$ 2.40
1 sq. 14"x30" shingles		.....	.....	19.00	19.00*
1¼ lb. nails		.....	.....	.30	.38
Roofer	2.0	.....	.....	7.00	14.00
Helper	1.0	.....	.....	5.00	5.00
Cost per 100 sq. ft. ...	3.0		$.....		$40.78†

If laid on a complicated or "cut-up" roof, add 1-hr. time for roofer and 0.5-hr. helper. Add for starters, hip and ridge shingles.

Applying Asbestos Shingles over Old Roofs.—When applying asbestos shingles over old roofs, it will be necessary to place wood strips or laths over the old roof. Figure about 300 lin. ft. of strips per 100 sq. ft. of roof, and 0.5 to 1-hr. time to place same.

Cutter for Asbestos Siding.—A small hand operated cutter for making either straight or angle cuts on asbestos shingles or siding may be purchased for $40.00 to $45.00, and will pay for itself many times on a job of any size.

ASBESTOS CEMENT SIDEWALL SHINGLES AND SIDING

Asbestos cement sidewall shingles and siding are manufactured from asbestos fibers and portland cement, which are formed into various shingle shapes under hydraulic pressure.

They are furnished in various colors and white, and are wood

*Shingle prices vary due to size, thickness, texture and color. Always obtain delivered prices in your locality before submitting bids. Also add for starter shingles, hips, ridges, etc.

†If roofing is sublet, add for roofing contractor's overhead expense and profit, which may vary from 30 to 40 percent.

grained to represent wood shingles and siding, and are used on both new and old work.

Asbestos cement siding shingles are furnished in strips 12"x24", 12"x27" or 32"x14⅝" and may be obtained with either staggered or thatched butts or with a wavy edge.

Estimating Data on Asbestos Cement Shingle Siding

Description Textured or Smooth	Dimensions	No. Req'd Per Sq.	Exposure Inches	Price Per Sq.
Rock Shakes	24x12	54	11	$20.00
Rock Shakes	32x14⅝	33	13⅝	20.00
Rock Shakes	32x 9	57	8	22.00
Textured Only				
Wavy Butt	24x12	54	11	20.00
Smooth Only				
Sheet	32x96	47	*	18.00

*Use 3½" backer strips.
Nails are furnished with shingles.

Special alloy nails for exposed nailing and asphalt joint strips are usually furnished by the manufacturers and are included in the price of the siding.

Labor Placing Asbestos Shingles on Sidewalls.—The labor cost of placing asbestos shingle siding will vary with the size of the shingle and the type of building, whether one having fairly long straight walls or one cut up with numerous openings requiring considerable cutting and fitting.

Where the old walls are crooked and it is necessary to straighten the old walls and place furring strips on same ready to receive the shingles, an extra allowance should be made for this work. Figure about 1.25 lin. ft. of furring to each square foot of siding.

Before placing asbestos shingles on sidewalls, the walls should first be covered with a heavy insulating and sheathing felt to keep out air and wind and prevent the penetration of water.

After the walls have been covered with paper, the courses of shingles should be marked with a chalk line, with the tops of the shingles following the chalk line. This will result in straight courses and a satisfactory job.

An asbestos siding cutter should be used for cutting siding as it will result in lower labor costs and prevent breakage. A hand operated cutter may be purchased for $40.00 to $45.00.

On straight sidewalls using 24"x12" shingles, a carpente should place 250 to 300 sq. ft. per 8-hr. day. On complicate work requiring considerable cutting, figure 150 to 200 sq. ft. pe 8-hr. day. Where 32"x14⅝" shingles are used, figure 375 t 425 sq. ft. per 8-hr. day for straight walls and 225 to 275 sq. f per 8-hr. day for cut-up work.

If wood stripping is required for nailing siding, add extr for strips and labor applying same.

Cost of 100 Sq. Ft. (1 Sq.) 24"x12" Asbestos Sidewall Siding o Straight Walls

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt.....		$.....	$.....	$ 2.40	$ 2.40
1 sq. 24"x12" shingle siding		.....	.....	20.00	20.00
1.25 lbs. nails.....		.....	.....	.30	.38
Carpenter	3	.....	.....	6.75	20.25
Cost per 100 sq. ft.....	3		$.....		$43.03

On jobs requiring considerable cutting and fitting, add 1.5-hrs carpenter time.

Colorbestos*.—Colorbestos is an asbestos-cement product manufactured in sheets 32" wide, 96" long and $\frac{3}{16}$" thick and is intended primarily for use as an exterior wall finish to be applied vertically from sill to plate. It is equally adaptable for soffits and exterior ceilings.

Colorbestos is available in light grey color.

The face of this material is textured with striations running the long dimension of the sheet accomplished by embedding colored granules in the asbestos-cement sheet. Although the sheet appears to have an ingrained texture, the surface is smooth to the touch.

Labor Placing Colorbestos.—Colorbestos is intended primarily for use on new construction and the large sheets are applied over a continuous backing of wood or non-wood sheathing. The sheets are applied with the vertical joints butted. Horizontal joints are lapped or may be butted when flashed with a "Z" type, non-corroding metal flashing. Exterior corners may be finished with either wood or metal trim.

Each sheet has 33 nail holes, $\frac{1}{8}$" in diameter, pre-punched at

*Johns-Manville, New York, N. Y.

the factory, along the sides and down the center. Where non-wood sheathing is used, studs must be accurately spaced 16" on center to permit nails to be driven through the sheathing into the studs; studs should be centered behind all vertical joints. Both wood and non-wood sheathing should first be covered with No. 15 asphalt saturated felt lapped 2" at horizontal joints and 6" at vertical joints. Nails, for fastening sheets, should be of non-corroding metal such as aluminum, etc.

Field cutting of Colorbestos is usually done by the "score and snap" method. Using a carbide tipped blade, a score mark is made in the surface of the sheet at the location of the cut and, with the sheet supported so that the edge of the support occurs under the cut-off line, the piece is snapped off cleanly. Cutting may also be accomplished by using a power saw equipped with a carbide tipped blade. To keep field cutting to a minimum, shorter factory-cut sizes may be ordered along with full size sheets.

If additional holes for nailing are required, they may be field punched using a sharpened nail set. However, holes close to the edge should be drilled.

Handling and placing full sheets of Colorbestos at ground level may be done by one man as a 32"x96" sheet weighs only 36 lbs. Each full sheet covers 21⅓ sq. ft. or 4.7 sheets provide 100 sq. ft. of finished surface. On ground story walls with a minimum of cutting, a carpenter should place 400 to 450 sq. ft. per 8-hr. day. Where the walls are cut up with door and window openings, a man should place 250 to 300 sq. ft. per 8-hr. day.

For gable ends, where each piece must be cut to fit the rake of the roof and placing must be done from a scaffold, two carpenters working together, should place 375 to 425 sq. ft. per 8-hr. day. For 1 story soffit and exterior ceiling work, a carpenter should place 300 to 350 sq. ft. per 8-hr. day.

Cost of 100 Sq. Ft. (1 Sq.) Colorbestos Siding on Ground Story Walls with a Minimum of Cutting

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$ 2.20	$ 2.20
105 sq. ft. Colorbestos.....		.....	.....	16.00	16.80
0.5 lb. aluminum nails.....		.....	.....	1.25	.63
Carpenter	1.9	.....	.....	6.75	12.83
Cost per 100 sq. ft.....	1.9		$.....		$32.46

For walls requiring cutting and fitting around door and window openings, add 1-hr. carpenter time.

Add cost of metal or wood corner trim.

Cost of 100 Sq. Ft. (1 Sq.) Colorbestos Siding on Gable Ends

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$ 1.20	$ 1.20
110 sq. ft. Colorbestos.....		.....	.....	16.00	17.60
0.5 lb. aluminum nails.....		.....	.....	1.25	.63
Carpenter	4	.....	.....	6.75	27.00
Cost per 100 sq. ft.....	4		$.....		$46.43

Add cost of scaffolding.

Cost of 100 Sq. Ft. (1 Sq.) Colorbestos on 1-Story Soffits or Ceilings

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$ 1.20	$ 1.20
105 sq. ft. Colorbestos.....		.....	.....	16.00	16.80
0.5 lb. aluminum nails.....		.....	.....	1.25	.63
Carpenter	2.5	.....	.....	6.75	16.88
Cost per 100 sq. ft.....	2.5		$.....		$35.51

TIN AND METAL ROOFING

Metal roofs include tin, copper, zinc, galvanized iron or steel or any of the special processes, such as Armco, Toncan, etc.

When estimating quantities of metal roofing, the measurements are taken in the same manner as for other types of roofs.

Where the metal roof is applied over flat roofs having parapet walls, an allowance of 1'-0" on each side and end of the wall should be allowed for flashing up the sides of the walls.

If metal roofing is applied to a flat surface or pitch roof with overhanging eaves the measurement is taken to cover the entire roof surface.

Do not make deductions for openings containing less than 100 sq. ft. and then deduct for just one-half the area of the opening, as the extra flashing costs as much as the roofing omitted.

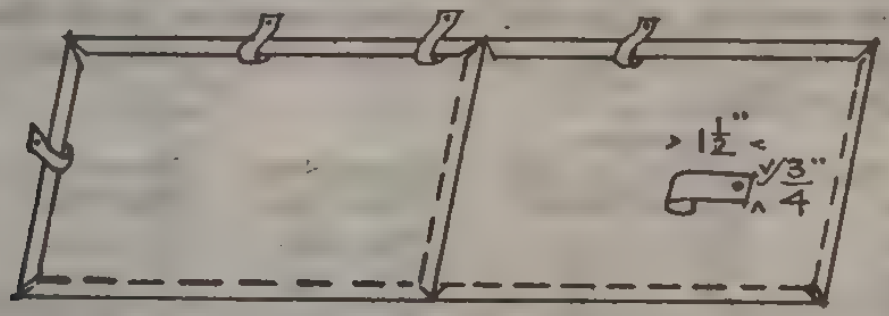
Deduct in full for all openings containing over 100 sq. ft.

Sizes of Sheets.—The common sizes of tin plates are 10"x14" or multiples of that size. The sizes generally used for roofing are 14"x20" and 20"x28". The larger sizes are more economical to lay, but for flat roofs the 20"x28" size is preferable.

For a flat seam roof, the edges of the sheets are turned in about ½", locked together and well soaked with solder. The

sheets should be fastened to the roof boards by cleats locked in the seams. These cleats are usually spaced about 8" apart and 2 nails are used in each cleat.

For flat seam roofing a 14"x20" sheet of tin, with edges turned up ½" on each side and end measures 13"x19" and contains 247 sq. in., but the covering capacity when locked to



Method of Laying Flat Seam Metal Roofing.

other sheets is only 12½"x18½" or 231¼ sq. in. It requires 62½ sheets of 14"x20" tin to cover 100 sq. ft. of roof.

Sheets measuring 20"x28" with the edges turned for flat seam roofing measure 19"x27" and when locked to other sheets have a covering capacity of 18½"x26½" or 490¼ sq. in. It requires 29½ sheets to cover 100 sq. ft. of roof.

Tin for roofs may also be obtained in rolls 14", 20", 24" and 28" wide. When used for flat seam roofing the loss due to turning edges amounts to 1½" on the width of any sheet.

Tin in 14" rolls loses 1½" or 11.2 percent of its width due to turning edges and laps. When estimating roofs using roll roofing, take the area of the roof and add 11 percent for waste. Another method is to take the length of the roof and divide by 12½" or 18½" (the net width of each sheet) and the result will be the number of strips of tin required. Multiply the number of strips by the length of each strip to obtain the quantity of tin required for any roof.

The following table gives the covering capacity and allowances for edging and laps to be figured when using tin roofing in rolls for flat seam roofs:

Width of Sheets Inches	Allowance for Edge and Laps	Actual Width Inches	Add for Loss Due to Edges and Laps	No. Sq. Ft. Required Per Sq.
14	1½	12½	12.0%	112
20	1½	18½	8.0%	108
24	1½	22½	7.0%	107
28	1½	26½	6.0%	106

The quantities of galvanized iron or steel sheets required for flat seam roofing will depend upon the size of the sheets, as they may be obtained in sheets from 24"x96" to 48"x120" in size.

The actual measurements of the sheets will be 1½" less in width and length than the size of the sheet used. For instance, the actual covering capacity of a 24"x96" sheet will be only 22½"x94½"=2,126 sq. in. or 14.76 sq. ft.

The following table gives the approximate covering capacity of one sheet of the different sizes, allowing 1½" in width and length for turning edge and lapping, together with the number of sheets of the different sizes required to cover one sq. (100 sq. ft.), of surface:

Size of Sheet Inches	Allowance for Edge of Lap Length	Allowance for Edge of Lap Width	Actual Size Sheet Ins.	Cover Cap. One Sheet	No. Sheets Per Sq.
24x 96	1½	1½	22½x 94½	14.76	6.8
24x120	1½	1½	22½x118½	18.51	5.4
26x 96	1½	1½	24½x 94½	16.08	6.2
26x120	1½	1½	24½x118½	20.16	5.0
28x 72	1½	1½	26½x 70½	13.00	7.7
28x 84	1½	1½	26½x 82½	15.18	6.6
28x 96	1½	1½	26½x 94½	17.40	5.8
28x108	1½	1½	26½x106½	19.60	5.1
28x120	1½	1½	26½x118½	21.80	4.6
30x 96	1½	1½	28½x 94½	18.70	5.4
30x120	1½	1½	28½x118½	23.45	4.3

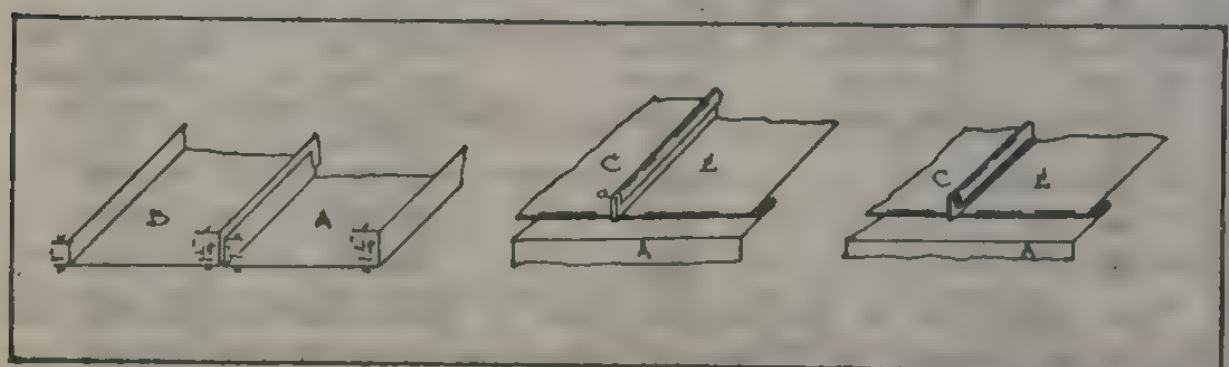
Standing Seam Metal Roofing.—Standing seam roofing requires a larger allowance for waste than flat seam roofing. The standing seam, edged 1¼" and 1½" takes 2¾" off the width and the flat cross seams edged ⅜", take 1⅛" off the length.

If 14"x20" tin is used, each sheet covers 11¼"x18⅜" or 212.34 sq. in. It requires 68 sheets of 14"x20" tin per 100 sq. ft. of roof.

If 20"x28" tin is used, each sheet covers 17¼"x26⅜" or 463.59 sq. in. It requires 32 sheets of 20"x28" tin per 100 sq. ft.

If roll tin is used 2¾" should be allowed for the two standing seams. The end waste will vary with the length of the sheets.

Tin in 14" rolls loses 2¾" off the width due to the standing



Method of Laying Standing Seam Metal Roofing

seams, making it necessary to add 20 percent for waste. Another method is to take the width of the roof and divide by 11¼" (the net width of the sheet), and the result is the number of strips of tin required. Multiply the number of strips by the length of the roof to obtain the quantity of tin required.

The following table gives the covering capacity and allowances for standing seams when estimating roll roofing:

Width of Sheets Inches	Allowance for Standing Seams	Actual Width Inches	Add for Loss Due to Standing Seams	No. Sq. Ft. Required Per Square
14	2¾	11¼	25%	125
20	2¾	17¼	16%	116
24	2¾	21¼	13%	113
28	2¾	25¼	11%	111

If galvanized steel or any of the special process metals, such as Armco, Toncan, etc., are used for standing seam roofs, an allowance of 1¼" and 1½" or a total of 2¾" should be taken from the width of the sheets to allow for standing seams. The cross seams edged ⅜" take 1⅛" off the length of each sheet. For instance, where 24"x96" sheets are used, the actual size of the sheets is 21¼"x94⅞" or each sheet will cover 2,016 sq. in. or 14 sq. ft.

The following table gives the covering capacity of painted or galvanized steel sheets of the different sizes:

Size of Sheet Inches	Standing Seam and End Lap Inches Width	Length	Actual Size Sheet Inches	Cover Cap. One Sheet Sq. Ft.	No. Sheets Per Square (100 Sq. Ft.)
24x 96	2¾	1⅛	21¼x 94⅞	14.00	7.2
24x120	2¾	1⅛	21¼x118⅞	17.54	5.7
26x 96	2¾	1⅛	23¼x 94⅞	15.33	6.6
26x120	2¾	1⅛	23¼x118⅞	19.20	5.3
28x 72	2¾	1⅛	25¼x 70⅞	12.43	8.1
28x 84	2¾	1⅛	25¼x 82⅞	14.52	6.9
28x 96	2¾	1⅛	25¼x 94⅞	16.65	6.0
28x108	2¾	1⅛	25¼x106⅞	18.75	5.4
28x120	2¾	1⅛	25¼x118⅞	20.82	4.8
30x 96	2¾	1⅛	27¼x 94⅞	17.92	5.6
30x120	2¾	1⅛	27¼x118⅞	22.50	4.5
36x 96	2¾	1⅛	33¼x 94⅞	22.00	4.6
36x120	2¾	1⅛	33¼x118⅞	27.45	3.7
42x 96	2¾	1⅛	39¼x 94⅞	25.85	3.9
42x120	2¾	1⅛	39¼x118⅞	32.40	3.1
48x 96	2¾	1⅛	45¼x 94⅞	29.80	3.4
48x120	2¾	1⅛	45¼x118⅞	37.40	2.7

V-Crimped Roofing.—V-crimped roofing is used the same as standing seam roofing, the V-crimp answering the same purpose as the standing seam.

Labor Placing 100 Sq. Ft. Flat and Standing Seam Tin and Metal Roofing

Description of Roof	Number Sq. Ft. per 8-Hr. Day	Hours per 100 Sq. Ft.	
		Tinner	Helper
Flat seam metal roofing, using 24″x96″ sheets or larger	300–350	2.5	2.5
Flat seam tin roofing, using 14″x20″ plates	175–225	4.0	4.0
Flat seam tin roofing, using 20″x28″ plates	225–275	3.3	3.3
Flat seam tin roofing, using 20″ tin in rolls	325–375	2.3	2.3
Flat seam tin roofing, using 14″ tin in rolls	275–325	2.8	2.8
Flat seam tin roofing, using 28″ tin in rolls	425–475	1.8	1.8
Standing seam metal roofing, using 24″x96″ sheets	250–300	3.0	3.0
Standing seam tin roofing, using 14″x20″ plates	125–175	5.3	5.3
Standing seam tin roofing, using 20″x28″ plates	175–225	4.0	4.0
Standing seam tin roofing, using 14″ tin in rolls	200–225	3.8	3.8
Standing seam tin roofing, using 20″ tin in rolls	250–300	3.0	3.0
Standing seam tin roofing, using 24″ tin in rolls	275–325	2.8	2.8
Standing seam tin roofing, using 28″ tin in rolls	300–350	2.4	2.4
V-Crimped metal roofing, using 24″x96″ sheets or larger	425–475	1.8	1.8

This roofing is usually furnished in sheets covering 24" in width and 6'-0" to 10'-0" long.

When estimating quantities of V-crimped roofing, allow for the end lap but there is no waste in the width as only the actual covering capacity is charged for by the manufacturers. For instance, a sheet 26" wide before crimping is 24" wide after crimping, but the sheet is sold as 24" wide.

The following table gives the quantity of V-crimp roofing required to cover 100 sq. ft. of roof with end laps 1" to 6":

Length of Sheet Feet	End Laps in Inches 1	2	3	4	5	6
	Square Feet of V-Crimp Roofing Required					
6	102	103	105	106	108	109
7	102	103	104	105	106	108
8	101	102	103	104	106	107
9	101	102	103	104	105	105
10	101	102	103	104	105	105

Cost of 100 Sq. Ft. (1 Sq.) Flat Seam Tin Roofing Using 14"x20" Plates

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt		$	$	$ 1.20	$ 1.20
63 shts. 14"x20" 20 lb. coated				.50	31.50
6 lbs. solder				.80	4.80
252 cleats				.01	2.52
2 lbs. nails				.30	.60
Flux and charcoal				1.20	1.20
Tinner	4			7.00	28.00
Helper	4			5.00	20.00
Cost per 100 sq. ft.	8		$		$89.82*

Cost of 100 Sq. Ft. (1 Sq.) Flat Seam Tin Roofing Using 20"x28" Plates

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt		$	$	$ 1.20	$ 1.20
29 shts. 20"x28" 20 lb. coated				.80	23.20
5 lbs. solder				.80	4.00
145 cleats				.01	1.45
1 lb. nails				.30	.30
Flux and charcoal				1.20	1.20
Tinner	3.3			7.00	23.10
Helper	3.3			5.00	16.50
Cost per 100 sq. ft.	6.6		$		$70.95*

*Add for ridges, hips, valleys, flashing, etc. and roofing contractor's overhead expense and profit.

Cost of 100 Sq. Ft. (1 Sq.) Flat Seam Tin Roofing Using Roll Roofing

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$ 1.20	$ 1.20
108 sq. ft. 20" roll rfg.....		.....	.....	.25	27.00
4 lbs. solder.....		.....	.....	.80	3.20
110 cleats		.....	.....	.01	1.10
1 lb. nails		.....	.....	.30	.30
Flux and charcoal.....		.....	.....	.90	.90
Tinner	2.3	.....	.....	7.00	16.10
Helper	2.3	.....	.....	5.00	11.50
Cost per 100 sq. ft.....	4.6		$.....		$61.30*

Cost of 100 Sq. Ft. (1 Sq.) Flat Seam Roofing Using 24"x96" Galvanized Steel Sheets

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$ 1.20	$ 1.20
7 shts. 26 ga. steel, 105 lbs.		.....	.....	.18	18.90
3 lbs. solder.....		.....	.....	.80	2.40
100 cleats		.....	.....	.01	1.00
1 lb. nails.....		.....	.....	.30	.30
Flux and charcoal.....		.....	.....	.60	.60
Tinner	2.5	.....	.....	7.00	17.50
Helper	2.5	.....	.....	5.00	12.50
Cost per 100 sq. ft.....	5.0		$.....		$54.40*

Cost of 100 Sq. Ft. (1 Sq.) Standing Seam Roofing Using 14"x20" Plates

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$ 1.20	$ 1.20
68 shts. 14"x20" 20-lb. coated		.....	.....	.50	34.00
100 cleats		.....	.....	.01	1.00
2.5 lbs. solder.....		.....	.....	.80	2.00
1 lb. nails.....		.....	.....	.30	.30
Flux and charcoal.....		.....	.....	.60	.60
Tinner	5.3	.....	.....	7.00	37.10
Helper	5.3	.....	.....	5.00	26.50
Cost per 100 sq. ft.	10.6		$.....		$102.70*

Cost of 100 Sq. Ft. (1 Sq.) Standing Seam Roofing Using 20"x28" Plates

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$ 1.20	$ 1.20
32 shts. 20"x28" 20-lb. coated		.....	.....	.80	25.60
Carried forward			$.....		$26.80

*Add for ridges, hips, valleys, flashing, etc. and roofing contractor's overhead expense and profit.

Standing Seam Roofing Using 20"x28" Plates—(Continued)

	Hours	Rate	Total	Rate	Total
Brought forward		$.....	$.....	$....	$26.80
80 cleats		.....	.....	.01	.80
2 lbs. solder		.....	.....	.80	1.60
1 lb. nails		.....	.....	.30	.30
Flux and charcoal		.....	.....	.60	.60
Tinner	4	.....	.....	7.00	28.00
Helper	4	.....	.....	5.00	20.00
Cost per 100 sq. ft.	8		$.....		$78.10*

Cost of 100 Sq. Ft. (1 Sq.) Standing Seam Roofing Using Roll Roofing

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt		$.....	$.....	$ 1.20	$ 1.20
116 sq. ft. 20" roll rfg.		.....	.....	.25	29.00
80 cleats		.....	.....	.01	.80
1 lb. solder		.....	.....	.80	.80
1 lb. nails		.....	.....	.30	.30
Flux and charcoal		.....	.....	.40	.40
Tinner	3	.....	.....	7.00	21.00
Helper	3	.....	.....	5.00	15.00
Cost per 100 sq. ft.	6		$.....		$68.50*

Cost of 100 Sq. Ft. (1 Sq.) Standing Seam Roofing Using 24"x96" Galvanized Steel Sheets

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt		$.....	$.....	$ 1.20	$ 1.20
8 shts. 26 ga. steel, 120 lbs.		.....	.....	.20	24.00
60 cleats		.....	.....	.01	.60
1 lb. solder		.....	.....	.80	.80
1 lb. nails		.....	.....	.30	.30
Flux and charcoal		.....	.....	.40	.40
Tinner	3	.....	.....	7.00	21.00
Helper	3	.....	.....	5.00	15.00
Cost per 100 sq. ft.	6		$.....		$63.30*

Cost of 100 Sq. Ft. (1 Sq.) V-Crimped Metal Roofing

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt		$.....	$.....	$ 1.20	$ 1.20
1 sq. 26 ga. V-crimped rfg.		.....	.....	20.00	20.00
5 lbs. lead headed nails		.....	.....	.60	3.00
60 lin. ft. wood strips		.....	.....	.025	1.50
Tinner	1.8	.....	.....	7.00	12.60
Helper	1.8	.....	.....	5.00	9.00
Cost per 100 sq. ft.	3.6		$.....		$47.30*

*Add for ridges, hips, valleys, flashing, etc. and roofing contractor's overhead expense and profit.

Roofing Contractor's Overhead Expense and Profit.—Please bear in mind that all prices given on tin, metal and copper roofing are actual costs to the contractor.

As this work is usually sublet by the general contractor to a sheet metal contractor, it will be necessary to add for the sheet metal contractor's overhead expense and profit.

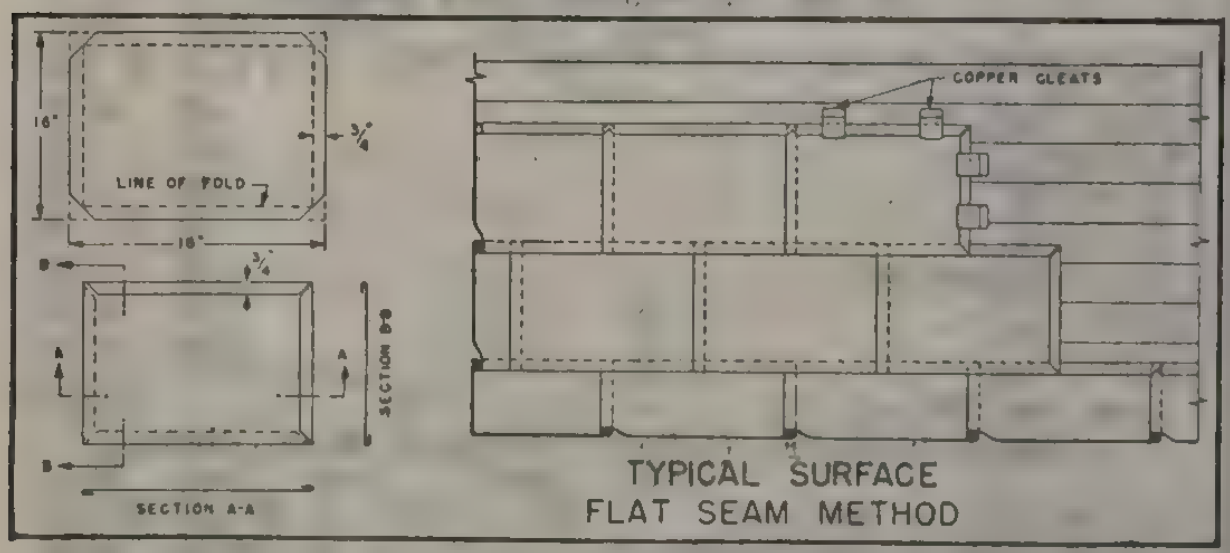
This is discussed in detail on the following pages under Sheet Metal Work.

COPPER ROOFING

The following information on the installation of Copper Roofing has been furnished through the courtesy of the Copper and Brass Research Association, New York, N. Y.

Copper may be used as roofing for any type of roof. There are various methods of applying copper for roofing, but most frequently used are the flat seam and standing seam methods. The batten seam method is also used, where durability is of more importance than cost, for cathedrals, government buildings, monumental structures, etc.

Flat Seam Roofing.— Flat seam roofing is commonly used on dead level or flat surfaces, but is adaptable to any slope. This method is also adaptable for the construction of water cooling roof panels, permitting water to stand up to a depth of 3 inches.



Method of Placing Flat Seam Copper Roofing.

For flat seam roofing, the use of small sheets of 20-oz., cold-rolled copper, not larger than 16"x18", with ¾" seams flat-locked and soldered, is recommended.

The accompanying illustration shows the method of laying flat seam roofing. The sheets are tinned on all edges, for soldering, and are then formed to lock ¾" with adjacent sheet. Corners

must be clipped to permit folding as shown. Opposite sides of the sheets are folded in opposite directions so they will hook into adjoining sheets.

The sheets are held down by 2" wide copper cleats, two on each of two adjacent sides. The other two sides are held by the edges of adjacent sheets already cleated. For small areas, it is general practice to use only three cleats, two on a long side and one on a short side.

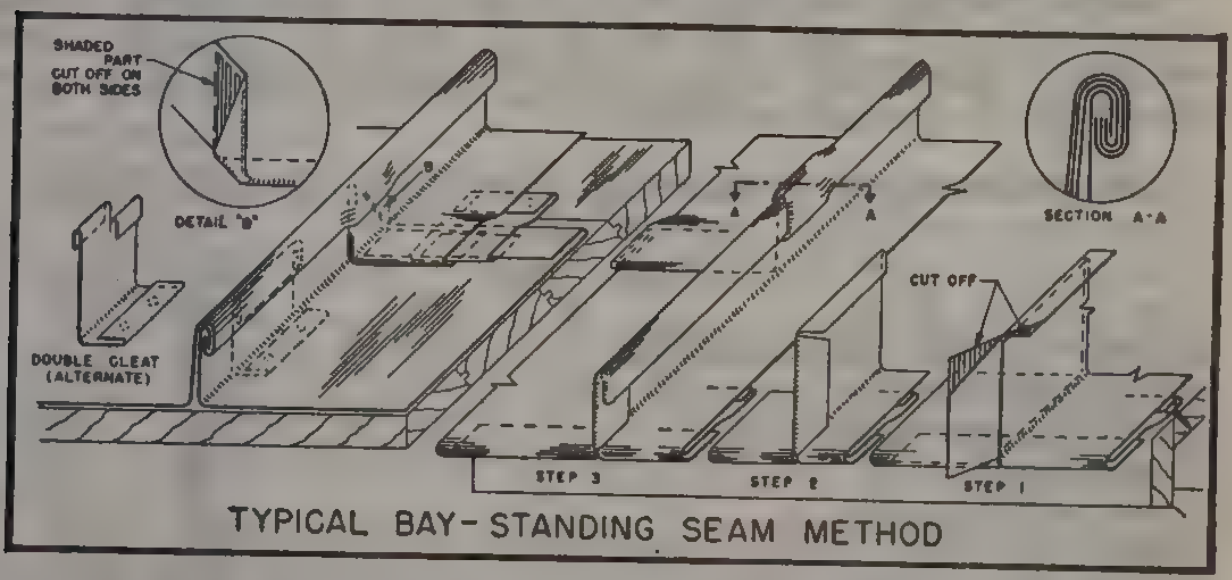
The cross seams are folded in the direction of flow. All seams should be flattened with a mallet and solder sweated to completely fill same.

Each 16"x18" sheet when folded covers 14½"x16½" or 239¼ sq. in. It requires 61 sheets of 16"x18" copper per 100 sq. ft. of roof.

Standing Seam Roofing.—Standing seam copper roofing may be used for surfaces with a minimum slope of 3" per foot. Standing seams are usually made to finish 1" high. The spacing of the seams is a matter of scale and architectural effect, but for economy, a choice should be made that will use sheets of stock sizes. The use of 20"x96" sheets is recommended as maximum for ordinary purposes.

For standing seams to finish 1" high, the vertical bends are made on the long edges of the sheets—1¾" on one side and 1½" on the other, the short bend on the one sheet always adjoins the long bend on the adjacent sheet.

Recommended weights of material are: 16-oz. for widths between seams up to 20"; 20-oz. for widths over 20".



Method of Placing Standing Seam Copper Roofing.

Formed pans are held to the roof deck with 2"x3" cleats spaced 12" apart and locked into the standing seam as shown in the

accompanying illustration. Transverse joints should be staggered and each secured with one cleat locked into the flat seam.

Standing seams should not be riveted or soldered—cross seams should be left unsoldered whenever conditions permit.

A sheet loses 3¼" in width on account of the standing seam, i.e. a sheet 20" wide would cover only 16¾". Where 20" sheets are used, add 20 percent to roof area for standing seams.

The loss at the end of the sheet will depend upon the length of the roof and the length of copper sheet used but allow 1½" for each flat seam.

Sizes and Weights of Copper Sheets Commonly Used in Building Work

Size of Sheet Copper	Weight in Pounds per Sheet of Various Weight Copper			
	16-Oz.	20-Oz.	24-Oz.	32-Oz.
20"x96"	13.33	16.67	20.00	26.67
24"x96"	16.00	20.00	24.00	32.00
30"x96"	20.00	25.00	30.00	40.00
36"x96"	24.00	30.00	36.00	48.00
20"x120"	16.67	20.83	25.00	33.33
24"x120"	20.00	25.00	30.00	40.00
30"x120"	25.00	31.25	37.50	50.00
36"x120"	30.00	37.50	45.00	60.00

Labor Placing Flat Seam Copper Roofing.—When using 16"x 18" copper sheets for flat seam roofing, a tinner and helper should place 175 to 225 sq. ft. of roof per 8-hr. day, on average size roofs.

Labor Placing Standing Seam Copper Roofing.—When using copper sheets 20" wide and up to 8'-0" long for standing seam roofing, a tinner and helper should place 200 to 250 sq. ft. per 8-hr. day, on average size roofs.

Cost of 100 Sq. Ft. (1 Sq.) Flat Seam Copper Roofing Using 16"x18" Sheets

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt		$.....	$.....	$1.20	$ 1.20
61 shts. 16" x18" (20-oz.) 153 lbs.		.....	.....	1.50	229.50
250 copper cleats		.....	.....	.15	37.50
2 lbs. copper nails		.....	.....	2.00	4.00
6 lbs. solder		.....	.....	.80	4.80
Flux and charcoal		.....	.....	1.25	1.25
Tinner	4	.....	.....	7.00	28.00
Helper	4	.....	.....	5.00	20.00
Cost per 100 sq. ft.	8		$.....		$326.25*

*Add for ridges, hips, valleys, flashing, etc. and roofing contractor's overhead expense and profit.

Cost of 100 Sq. Ft. (1 Sq.) Standing Seam Copper Roofing Using 20" Copper

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$1.20	$ 1.20
120 sq. ft. (16-oz.) 120 lbs.		.....	.....	1.50	180.00
80 copper cleats.....		.....	.....	.15	12.00
1 lb. copper nails.....		.....	.....	2.00	2.00
Tinner	3.5	.....	.....	7.00	24.50
Helper	3.5	.....	.....	5.00	17.50
Cost per 100 sq. ft.....	7.0		$.....		$237.20*

*Add for ridges, hips, valleys, flashing, etc. and roofing contractor's overhead expense and profit.

CORRUGATED STEEL ROOFING AND SIDING

Corrugated steel is used extensively for roofing and siding steel mills, manufacturing plants, sheds, grain elevators and other industrial structures.

It is made with various corrugations but the 2½" corrugations are most commonly used.

The sheets are usually furnished 26" wide and 6'-0" to 12'-0" long. Some manufacturers offer siding protected with vinyl coatings.

When estimating quantities of corrugated siding or roofing, always select lengths that work to best advantage and be sure and allow for both end and side laps.

Corrugated siding or roofing is nailed to the wood framework or siding when used on wood constructed buildings. When used as a wall and roof covering on structural steel framing, the corrugated sheets are fastened to the steel framework, using clip and bolts, which are passed around or under the purlins (which usually consist of channels, angles or Z bars). When angles are used for purlins, clinch nails are sometimes used for fastening the corrugated sheets.

When used for siding one corrugation lap is usually sufficient, but for roofing two corrugations should be used and if the roof has only a slight pitch, the lap should be three corrugations.

When used for siding, a 1" to 2" end lap is sufficient, but when laid on roofs it should have an end lap of 3" to 6" depending upon the pitch of the roof. For a ⅓ pitch a 3" lap is sufficient; for a ¼ pitch a 4" lap should be used; and for a ⅛ pitch a 5" end lap.

When applying to wood sheathing or strips, the nails should be spaced about 8" apart at the sides. When applied to iron or steel purlins, the side laps should extend over at least 1½ corrugations, and the sheets should be riveted together every 8" on the sides and at every alternate corrugation on the ends.

Number of Sq. Ft. of Corrugated Sheets Required to Cover 100 Sq. Ft. of Surface, Using 26"x96" Sheets

2½-Inch Corrugation	Length of End Lap in Inches 1	2	3	4	5	6
	Square Feet of Corrugated Metal.					
Side lap, 1 corrugation	110	111	112	113	114	115
Side lap, 1½ corrugations	116	117	118	119	120	121
Side lap, 2 corrugations	123	124	125	126	127	128
Side lap, 2½ corrugations	130	131	132	133	134	135
Side lap, 3 corrugations	138	139	140	141	142	143

If shorter sheets are used the allowance should be slightly increased.

The following table states the gauges and sizes, together with the weight of both painted and galvanized sheets per 100 sq. ft. These weights are for 100 sq. ft. of metal and do not include allowances for side and end laps, so all weights and quantities should be increased as given in the previous table.

As an example, one square of No. 28 gauge galvanized sheets weighs 84 lbs. By referring to the previous table you will note it requires 110 sq. ft. of metal where the side lap is one corrugation and the end lap one inch, so the weight of sufficient metal to cover 100 sq. ft. of roof or wall area would be 110 multiplied by 84 lbs. or 92.4 lbs. per square.

Corrugated Steel Roofing and Siding

The following are for sheets with standard 2½" corrugations and cover 24", allowing for lap of one corrugation.

Gauge	Size	Galv. Wt. Per Sq.	No. Sh'ts Per Sq.
18	26x 72	232	7.692
	26x 84	232	6.593
	26x 96	232	5.769
	26x108	232	5.128
	26x120	232	4.616
20	26x 72	178	7.692
	26x 84	178	6.593
	26x 96	178	5.769
	26x108	178	5.128
	26x120	178	4.616
22	26x 72	151	7.692
	26x 84	151	6.593
	26x 96	151	5.769
	26x108	151	5.128
	26x120	151	4.616
24	26x 72	125	7.692
	26x 84	125	6.593
	26x 96	125	5.769
	26x108	125	5.128
	26x120	125	4.616
26	26x 72	98	7.692
	26x 84	98	6.593
	26x 96	98	5.769
	26x108	98	5.128
	26x120	98	4.616
27	26x 96	91	5.769
	26x120	91	4.616
28	26x 72	84	7.692
	26x 84	84	6.593
	26x 96	84	5.769
	26x108	84	5.128

Placing Corrugated Steel Roofing or Siding on Wood Framing.—If corrugated sheets used for roofing or siding are nailed to wood strips or framing, a man and helper should place 100 sq. ft. (1 sq.) of 26"x96" or larger, in ⅞ to 1⅛ hr. or 7 to 9 sqs. per 8-hr. day, at the following labor cost per 100 sq. ft. (1 sq.):

	Hours	Rate	Total	Rate	Total
Mechanic	1	$.....	$.....	$7.00	$7.00
Helper	1	.....	.....	5.00	5.00
Cost per 100 sq. ft.	2		$.....		$12.00

Labor cost will vary, depending upon side and end laps.

Cost of 100 Sq. Ft. (1 Sq.) Corrugated Metal Siding on Wood Framing

	Hours	Rate	Total	Rate	Total
110 sq. ft. 26 ga. 26"x96", 108 lbs.		$.....	$.....	$20.00	$22.00
1.5 lbs. lead headed nails		.....	.....	.80	1.20
Mechanic	1	.....	.....	7.00	7.00
Helper	1	.....	.....	5.00	5.00
Cost per 100 sq. ft.	2		$.....		$35.20

If necessary to erect scaffolding, add for this work.

Cost of 100 Sq. Ft. (1 Sq.) Corrugated Metal Roofing on Wood Framing

	Hours	Rate	Total	Rate	Total
125 sq. ft. 24 ga. 26"x96", 155 lbs.		$.....	$.....	$23.50	$29.38
1.5 lbs. lead headed nails		.....	.....	.80	1.20
Mechanic	1.2	.....	.....	7.00	8.40
Helper	1.2	.....	.....	5.00	6.00
Cost per 100 sq. ft.	2.4		$.....		$44.98

Placing Corrugated Steel Roofing on Steel Framing.—The labor cost of applying corrugated steel roofing to structural steel framing where the sheets are fastened with clips or rivets, will vary with the size of the roof area, regularity of roof, height above ground, etc., but on a straight job, a sheeter and bucker-up should place 550 to 650 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor handling, hoisting	2.67	$.....	$.....	$5.00	$13.35
Sheeter	1.33	.....	.....	7.00	9.31
Bucker-up	1.33	.....	.....	7.00	9.31
Cost per 100 sq. ft.	5.33		$.....		$31.97

On irregular roofs, above costs may be increased 25 to 50%.

Placing Corrugated Steel Siding on Steel Framing.—The labor cost of applying corrugated steel siding to walls will vary greatly

according to length and height of walls, quantity and regularity of openings, etc., but on a straight job, a sheeter and bucker-up should place 450 to 550 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Labor handling, hoisting..	3.2	$.....	$.....	$5.00	$16.00
Sheeter	1.6	.....	.....	7.00	11.20
Bucker-up	1.6	.....	.....	7.00	11.20
Cost per 100 sq. ft.....	6.4		$.....		$38.40

On coal tipples, grain elevators and other structures having high and irregular walls, the above costs may be doubled.

Cost of 100 Sq. Ft. (1 Sq.) Corrugated Metal Roofing on Steel Framing, Straight Work

	Hours	Rate	Total	Rate	Total
125 sq. ft. 20 ga. 26"x96", 204 lbs.		$.....	$.....	$28.00	$35.00
Rivets or clips, 12 lbs.....		.....	.....	.80	9.60
Labor handling, hoisting..	2.67	.....	.....	5.00	13.35
Sheeter	1.33	.....	.....	7.00	9.31
Bucker-up	1.33	.....	.....	7.00	9.31
Cost per 100 sq. ft.....	5.33		$.....		$76.57

Add extra labor for high or irregular roof area.

Cost of 100 Sq. Ft. (1 Sq.) Corrugated Metal Siding on Steel Framing, Straight Work

	Hours	Rate	Total	Rate	Total
110 sq. ft. 24 ga. 26"x96", 138 lbs.		$.....	$.....	$23.50	$25.85
Rivets or clips, 10 lbs.....		.....	.....	.80	8.00
Labor handling, hoisting..	3.2	.....	.....	5.00	16.00
Sheeter	1.6	.....	.....	7.00	11.20
Bucker-up	1.6	.....	.....	7.00	11.20
Cost per 100 sq. ft.....	6.4		$.....		$72.25

Add extra labor for high and irregular walls such as grain elevators, coal tipples, conveyor housing, etc.

Galbestos* Roofing and Siding

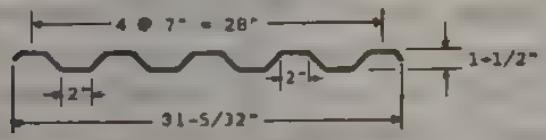
Galbestos consists of a steel core sheet to which asbestos felt is bonded by hot molten zinc. When the zinc has cooled, the asbestos felt and the steel core are metallurgically bound together. The felt is then impregnated with asphalt saturant. Finally, a tough, thick, waterproof outer coating is applied. All material is made with protective coating both sides.

There are eight colors to choose from: white, light green, blue,

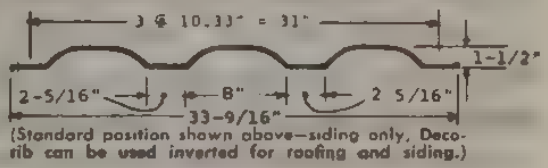
*H. H. Robertson Company, Pittsburgh, Pa.

brown, light grey, dark grey, maroon and black. Galbestos is manufactured in 4 gauges: 18, 20, 22 and 24,* and is available in lengths up to 30 feet.

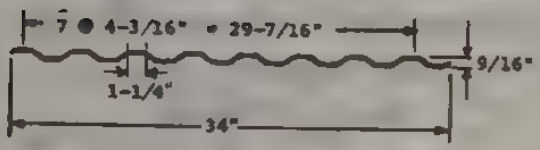
Estimating and Cost Data.—Galbestos sheets are available in 5 profiles including: Huski-Rib, Decorib, Sturdirib, Mansard, and Corrugated.



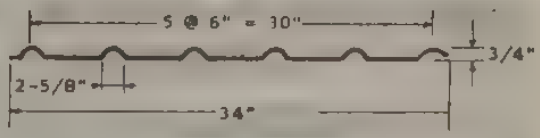
HUSKI-RIB®



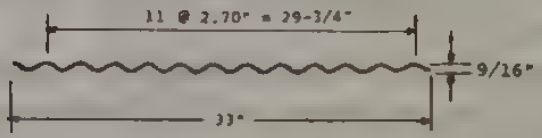
DECORIB®



STURDI-RIB®



MANSARD



CORRUGATED

Profiles of Robertson Galbestos Roofing and Siding

Huski-Rib has a deep fluted profile, designed specifically for high strength long span roofing and siding installations. The Huski-Rib sheet is $31\frac{5}{32}$" wide x $1\frac{1}{2}$" deep, and provides a coverage of 28". It is manufactured in 18, 20, 22 and 24 gauge metal a maximum of 30' long, and is suitable for spans up to 15'-10" for siding, and up to 14'-8" for roofing depending upon local load requirements.

Decorib has wide curved flutes providing a pleasant pattern for all types of buildings. The standard sheet is $33\frac{9}{16}$" wide x $1\frac{1}{2}$" deep and provides a coverage of 31". It is manufactured in 18, 20 and 22 gauge metal and is available in up to 30' lengths. Decorib may be used for spans up to 14'-11" for siding, and up to 12'-11" for roofing. Panels must be inverted for use as roofing and may be used inverted for siding.

* Decorib and Mansard not available in 24 ga.

Sturdi-Rib sheets come 34" wide x $\frac{9}{16}$" deep providing a coverage of 29$\frac{7}{16}$", and are made in lengths up to 30 feet. They are made of 18, 20, 22, and 24 gauge metal and are capable of spanning up to 10'-1" for siding and 8'-9" for roofing installations, depending upon local load requirements.

The Mansard profile sheets are 34" wide x $\frac{3}{4}$" deep providing a coverage of 30" installed. They come in 18, 20 and 22 gauge metal in lengths up to 30 feet. Mansard sheets are capable of spanning up to 8'-5" for siding and 7'-3" for roofing installations.

Corrugated Galbestos is the original Robertson protected metal profile and comes in sheets 33" wide x $\frac{9}{16}$" deep. Coverage is 29$\frac{3}{4}$". Corrugated sheets are available in 18, 20, 22 and 24 gauge metal in lengths up to 30 feet. They are capable of spanning up to 8'-4" for siding and 6'-10" for roofing installations.

Approximate Price per Sq. Ft. of Corrugated Galbestos Sheets in Quantities of 10,001 to 20,000 Sq. Ft.

Description	Gauge of Sheets 18	20	22	24
Galbestos C2S (Asphalt) Black ..	$0.62	$0.55	$0.52	$0.45
Galbestos C2S (Resin) Color ..	.74	.67	.63	.53

After figuring the price of sheets from the above, approximately 25 percent should be added to cover cost of flashings, fastenings, closures, corners, etc.

True cost comparisons must include the cost of supporting steel girts or purlins. Longer spans of Galbestos may save up to $0.15 per sq. ft. or more.

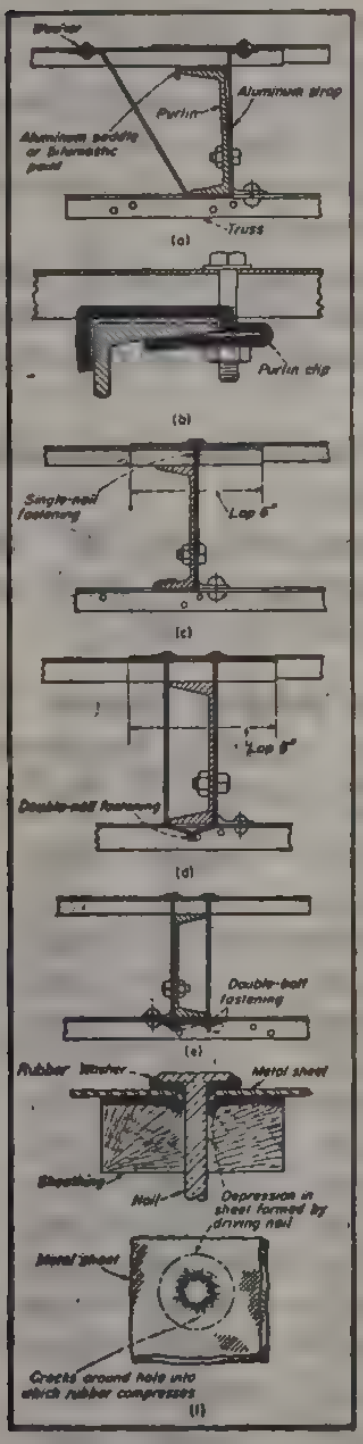
Matching profiled translucent fiberglass reinforced plastic daylight panels "Stypolight" are available with Galbestos.

ALUMINUM ROOFING AND SIDING

When using aluminum roofing and siding, it is very important when applying the sheets that they be insulated against electro-galvanic action. Ordinarily aluminum has a high resistance to corrosion but when it is contiguous to steel or copper in the presence of moisture, an electrolytic cell is formed and the resulting flow of current dissolves the aluminum, causing severe pitting. This condition can be avoided by preventing metal-to-metal contact.

Another significant requirement in using aluminum sheet is to seal the openings made for the fastening devices. Methods for achieving this objective effectively include the use of special washers and waterproof roofing compounds. Washers should be used with fasteners to distribute stresses and prevent tearing of the sheet.

To provide adequate drainage, the roof surface should never have a slope less than 2½-in. per ft. and preferably not less than 3-in. per ft.



Types of Fasteners Available for Corrugated Aluminum Roofing and Siding.

For roofing, sheets should have a side lap of 1½ corrugations. For siding, sheets should be lapped 1 corrugation.

A 6-in. overlap at the ends is recommended for roofing and 4-in. for siding.

When corrugated aluminum sheets are used without sheathing on a steel frame, the method shown in (a) is suggested for fastening to purlins and girts. This method utilizes aluminum straps, 12-in. apart, with aluminum bolts and nuts, aluminum rivets or cadmium-plated steel bolts.

To prevent galvanic action, direct contact between the top of the purlin and roofing should be prevented preferably by insertion of an aluminum saddle or by painting the flange of the purlin with aluminum or bitumastic paint. Roofing paper may also be used to separate the metals.

Purlin clips (b) are also widely used as a fastening device. The U bend is slipped over the purlin flange and a leg hammered down against the web to lock the clip in place. The roofing is bolted to the clip. If standard steel purlin clips are used, they should be hot-dip galvanized.

Purlin nails, either single (c) or double (d) are also used for anchoring sheeting. A variation of this method employing aluminum washers, nuts and base plate under the purlin is shown in (e).

The best method of nailing to sheathing is to use galvanized roofing nails about 1¾-in. long with a head about ⅜-in. in diameter, spaced at 8-in. intervals. These nails should have a hot-dip zinc coating.

Corrugated sheets should always be riveted, bolted or nailed through the top of a corrugation. The reason is that rain running down the roof tends to collect in the bottom of corrugations and would penetrate imperfectly sealed holes there. At the top, water runs away from the holes.

A washer of non-metallic material, such as zinc chromate impregnated fabric, neoprene or other rubber should be employed under a nailhead. The purpose of this washer is to prevent metal-to-metal contact between the under side of the head and the roofing sheet, to seal the opening made in the sheet and to permit thermal expansion and contraction of the sheeting.

Hot-dip galvanized nails without washers may be used when washers are not available. Roofing nails with cast-on lead heads can be used in other than industrial or seacoast corrosive atmospheres.

Sizes, Weights and Coverage Data on Corrugated Aluminum Sheets Used for Roofing

Lengths, 5'-0" to 14'-6" in 6" increments. Widths, 35" and 48⅜". Thicknesses, .024" and .032". Corrugation, 2.67" pitch and ⅞" deep. Coverage, 32" for 35" width and 45⅜" for 48⅜".

Data on .032" Corrugated Aluminum Roofing Sheets

Sheet Length in Feet	Square Feet per Sheet		Weight per Sheet in Lbs.		Approx. No. Sheets* per 100 Sq. Ft.	
	35"	48⅜"	35"	48⅜"	35"	48⅜"
5	14.58	20.16	8.04	11.03	6.86	4.96
5½	16.04	22.17	8.85	12.13	6.23	4.51
6	17.50	24.19	9.65	13.24	5.71	4.13
6½	18.96	26.20	10.46	14.34	5.27	3.82
7	20.42	28.22	11.26	15.44	4.90	3.54
7½	21.88	30.23	12.07	16.55	4.57	3.31
8	23.33	32.25	12.87	17.65	4.29	3.10
8½	24.79	34.27	13.68	18.75	4.03	2.92
9	26.25	36.28	14.48	19.86	3.81	2.76
9½	27.71	38.30	15.29	20.96	3.61	2.61
10	29.17	40.31	16.09	22.06	3.43	2.48
10½	30.63	42.33	16.90	23.16	3.26	2.36
11	32.08	44.34	17.70	24.27	3.12	2.26
11½	33.54	46.36	18.51	25.37	2.98	2.16
12	35.00	48.37	19.31	26.47	2.86	2.07

For .024" thickness use data given above except reduce weights 25 percent.

*For side and end lap allowance, add approximately 16% for 35" width and 12% for 48⅜" width.

Sizes, Weight and Coverage Data on Corrugated Aluminum Sheets Used for Siding

Lengths, 5'-0" to 12'-0" in 6" increments. Widths, 33¾" and 47⅛". Thicknesses, .024" and .032". Corrugation, 2.67" pitch and ⅞" deep. Coverage, 32" for 33¾" width and 45⅜" for 47⅛" width.

Data on .032" Corrugated Aluminum Siding Sheets

Sheet Length in Feet	Square Feet per Sheet		Weight per Sheet in Lbs.		Approx. No. Sheets* per 100 Sq. Ft.	
	33¾"	47⅛"	33¾"	47⅛"	33¾"	47⅛"
5	14.06	19.64	7.76	10.75	7.11	5.09
5½	15.47	21.60	8.54	11.82	6.46	4.63
6	16.87	23.56	9.31	12.90	5.93	4.24
6½	18.28	25.53	10.09	13.97	5.47	3.92
7	19.69	27.49	10.87	15.05	5.08	3.64
7½	21.09	29.45	11.65	16.12	4.74	3.40
8	22.50	31.42	12.42	17.20	4.44	3.18
8½	23.91	33.38	13.20	18.27	4.18	3.00
9	25.31	35.34	13.97	19.35	3.95	2.83
9½	26.72	37.31	14.75	20.42	3.74	2.68
10	28.12	39.27	15.52	21.50	3.56	2.55
10½	29.53	41.23	16.30	22.57	3.39	2.43
11	30.94	43.20	17.08	23.65	3.23	2.31
11½	32.34	45.16	17.86	24.72	3.09	2.21
12	33.75	47.13	18.63	25.80	2.96	2.12

For .024" thickness use data given above, except reduce weights 25 percent.

*For side and end lap allowance, add approximately 9% for 33¾" width and 6% for 47⅛" width.

Data on Nails Required for Roofing

Kind of Nail	Length Inches	Number per Lb.	Price per Lb.
Galvanized Needle Point	1¾"	83	$0.42
Galvanized Needle Point	2 "	77	.42
Aluminum Nails—Neoprene Washers	1¾"	318	1.90
Aluminum Nails—Neoprene Washers	2 "	285	1.90

Labor Placing Corrugated Aluminum Roofing and Siding.—Estimate about the same labor cost for erecting aluminum corrugated roofing and siding as given on the previous pages under "Corrugated Steel Roofing and Siding."

Aluminum is much lighter than steel but the labor operations are practically the same.

Approximate Prices Per 100 Lbs. of Corrugated Aluminum Roofing and Siding

Finish	Price
Mill finish	$70.00
Embossed finish	72.00

After figuring the price of sheets from the above, approximately 20 percent should be added to cover cost of closures, flashings, fillers, corners, etc.

Cost of 100 Sq. Ft. (1 Sq.) Corrugated Aluminum Siding on Wood Framing.

Based on using sheets 33¾" wide, .032" thick, weighing .552 lbs. per sq. ft.

	Hours	Rate	Total	Rate	Total
109 sq. ft. corr. siding, 60 lbs.		$.....	$.....	$0.70	$42.00
1.5 lb. galv. nails.....		.....	.....	.42	.63
Mechanic	1	.....	.....	7.00	7.00
Helper	1	.....	.....	5.00	5.00
Cost per 100 sq. ft.....	2		$.....		$54.63

Add for closures, corners, flashings, etc. Add for extra scaffolding.

Cost of 100 Sq. Ft. (1 Sq.) Corrugated Aluminum Roofing on Wood Framing

Based on using sheets 35" wide, .032" thick, weighing .552 lbs. per sq. ft.

	Hours	Rate	Total	Rate	Total
116 sq. ft. corr. siding, 64 lbs.		$.....	$.....	$0.70	$44.80
1.5 lb. galv. nails.....		.....	.....	.42	.63
Mechanic	1.2	.....	.....	7.00	8.40
Helper	1.2	.....	.....	5.00	6.00
Cost per 100 sq. ft.....	2.4		$.....		$59.83

Add for ridge roll, side wall flashings, etc. Add for extra scaffolding.

Cost of 100 Sq. Ft. (1 Sq.) Corrugated Aluminum Siding on Steel Framing, Straight Work

Based on using sheets 33¾" wide, .032" thick, weighing .552 lbs. per. sq. ft.

	Hours	Rate	Total	Rate	Total
109 sq. ft. corr. siding, 60 lbs.		$.....	$.....	$0.70	$42.00
Rivets, clips, straps.....		.....	.....	7.00	7.00
Labor handling-hoisting..	3.2	.....	.....	5.00	16.00
Sheeter	1.6	.....	.....	7.00	11.20
Bucker-up	1.6	.....	.....	7.00	11.20
Cost per 100 sq. ft.....	6.4		$.....		$87.40

Add extra labor for high and irregular walls such as grain elevators, conveyor housing, etc. Add for closures, flashings, etc.

Cost of 100 Sq. Ft. (1 Sq.) Corrugated Aluminum Roofing on Steel Framing, Straight Work

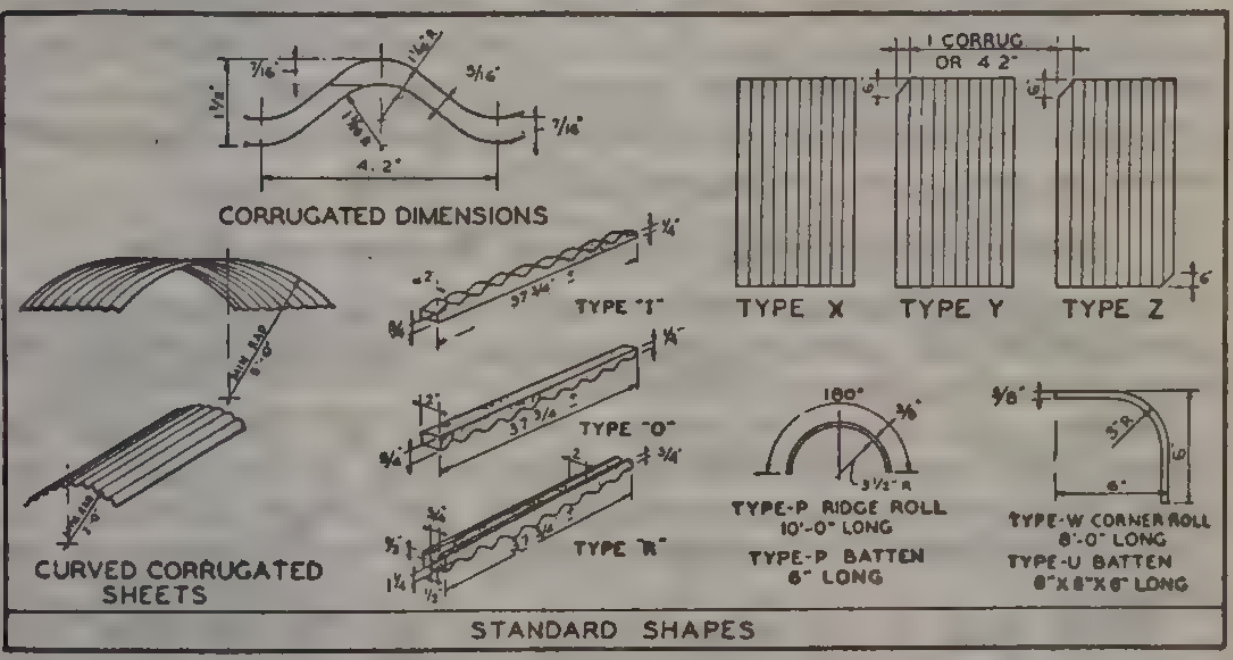
Based on using sheets 35" wide, .032" thick, weighing .552 lbs. per. sq. ft.

	Hours	Rate	Total	Rate	Total
116 sq. ft. corr. siding, 64 lbs.		$.....	$.....	$0.70	$44.80
Rivets, clips, straps.....		.....	.....	7.00	7.00
Labor handling-hoisting.	2.67	.....	.....	5.00	13.33
Sheeter	1.33	.....	.....	7.00	9.33
Bucker-up	1.33	.....	.....	7.00	9.33
Cost per 100 sq. ft.....	5.33		$.....		$83.79

Add extra labor for high or irregular roof areas. Add for closures, flashings, etc.

CORRUGATED ASBESTOS ROOFING AND SIDING

Corrugated asbestos roofing and siding is used over skeleton frame construction that can be applied with the minimum of time and labor. It is composed of asbestos fiber and port-



Types of Corrugated Asbestos Roofing and Siding.

land cement combined under great hydraulic pressure into homogeneous sheets of a light gray color, structurally strong, comparatively light in weight and possessing the highest qualities of resistance to all of the forces of rot and decay.

The same materials that are used in forming the corrugated sheets are molded at the factory into special standard shapes to be used as ridge roll, corner roll, louvers and ventilators.

Standard sheets have corrugations with a 4.2" pitch and a depth of 1½". The thickness is approximately $\frac{7}{16}$" at ridge and valley of corrugations and approximately $\frac{5}{16}$" on tangent, an average thickness of $\frac{3}{8}$". Sheets are furnished 42", or ten corrugations, wide. Standard lengths are 0'-6" to 12'-0" in 6" increments. Sheets can be furnished on special order cut to any desired length possible from the standard sizes. Special curved sheets can also be furnished with the following limitations: sheets may be curved longitudinally, the arc being formed along the direction of the corrugation; minimum radius when so curved 60". Sheets may be curved crosswise, the arc being formed across the corrugations, minimum radius when so curved 24". Sheets may be curved either way but not in combination. The sheets are furnished in three types, as illustrated. The cut corner construction eliminates a thickness of material in the corner lap, thus allowing the sheets to nest perfectly at these points and permit them to be laid with side laps forming vertical lines. The inside and outside radii of the corrugations are the same, thereby allowing the sheets to nest perfectly at all laps.

Corrugated asbestos roofing should not be laid on roofs having a pitch of less than 3" per foot; a pitch of 4" or more is preferred. Asbestos roof putty should be used in all laps.

Supporting purlins or girts should be spaced not to exceed 54" center to center for roofing and 66" for siding.

Method of Applying Corrugated Roofing and Siding

Corrugated asbestos roofing and siding is applied directly over purlins and girts of skeleton frame construction or may be applied over solid wood sheathing.

When used as either roofing or siding, all sheets shall be lapped one corrugation at the sides and 6" at the ends. The size of the end lap is governed by the cut corner construction. The width of weather exposure of sheets for estimating purposes is 37.8".

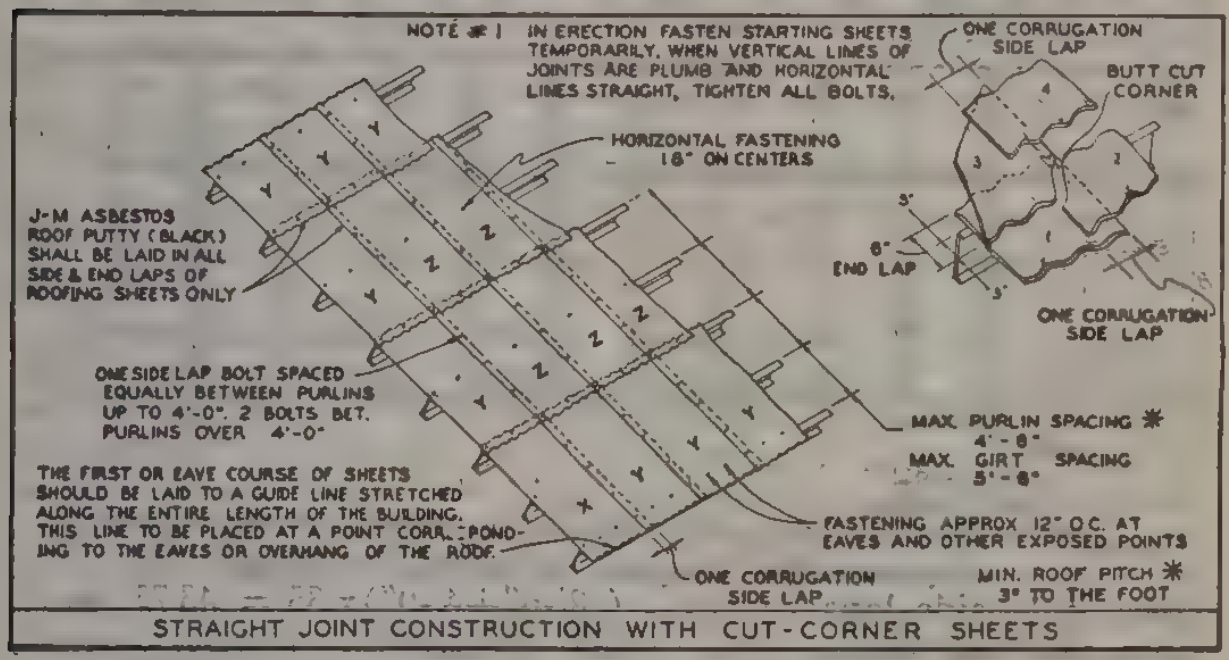
Sheets shall be of proper length so that all end laps will occur over a purlin or girt and so that fasteners at ends of sheets will pass through both upper and underlying sheets.

Fasteners especially designed for use in connection with this material can be furnished by the manufacturer. The style of fastener to be used will be governed by the type, shape and position of purlins and girts. Sheets shall be secured at all purlins and girts, spacing fasteners as follows:

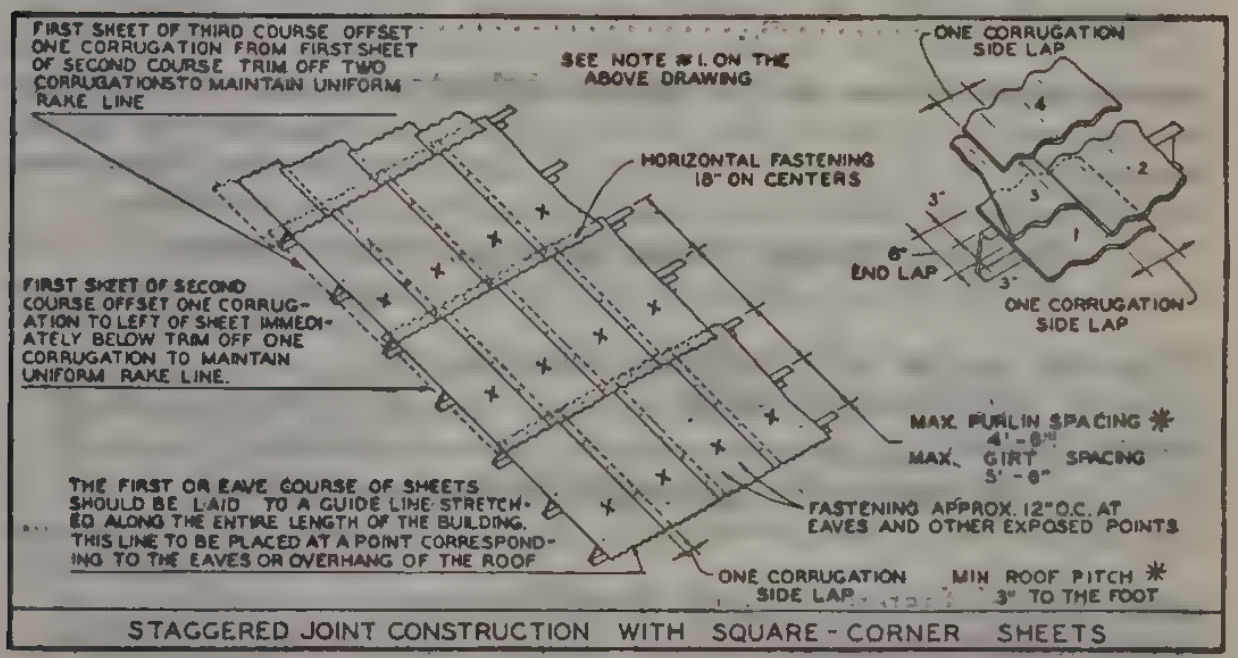
Clips, spaced approximately 18" center to center on main body of roof and 12" along eaves and on unusually exposed

areas. Drive screws and nails spaced approximately 12" center to center, side lap bolts spaced one in each side lap midway between purlins or girts on spans not exceeding 48", and two evenly spaced on greater spans.

Flat washers must be used wherever head or top of fasteners come in contact with the asbestos material and heads of all


NOTE #1 IN ERECTION FASTEN STARTING SHEETS TEMPORARILY. WHEN VERTICAL LINES OF JOINTS ARE PLUMB AND HORIZONTAL LINES STRAIGHT, TIGHTEN ALL BOLTS.
ONE CORRUGATION SIDE LAP
BUTT CUT CORNER
HORIZONTAL FASTENING 18" ON CENTERS
J-M ASBESTOS ROOF PUTTY (BLACK) SHALL BE LAID IN ALL SIDE & END LAPS OF ROOFING SHEETS ONLY
3"
6" END LAP
3"
ONE CORRUGATION SIDE LAP
ONE SIDE LAP BOLT SPACED EQUALLY BETWEEN PURLINS UP TO 4'-0". 2 BOLTS BET. PURLINS OVER 4'-0"
MAX. PURLIN SPACING * 4'-8"
MAX. GIRT SPACING 5'-8"
THE FIRST OR EAVE COURSE OF SHEETS SHOULD BE LAID TO A GUIDE LINE STRETCHED ALONG THE ENTIRE LENGTH OF THE BUILDING. THIS LINE TO BE PLACED AT A POINT CORRESPONDING TO THE EAVES OR OVERHANG OF THE ROOF.
FASTENING APPROX. 12" O.C. AT EAVES AND OTHER EXPOSED POINTS
ONE CORRUGATION SIDE LAP
MIN. ROOF PITCH * 3" TO THE FOOT
STRAIGHT JOINT CONSTRUCTION WITH CUT-CORNER SHEETS

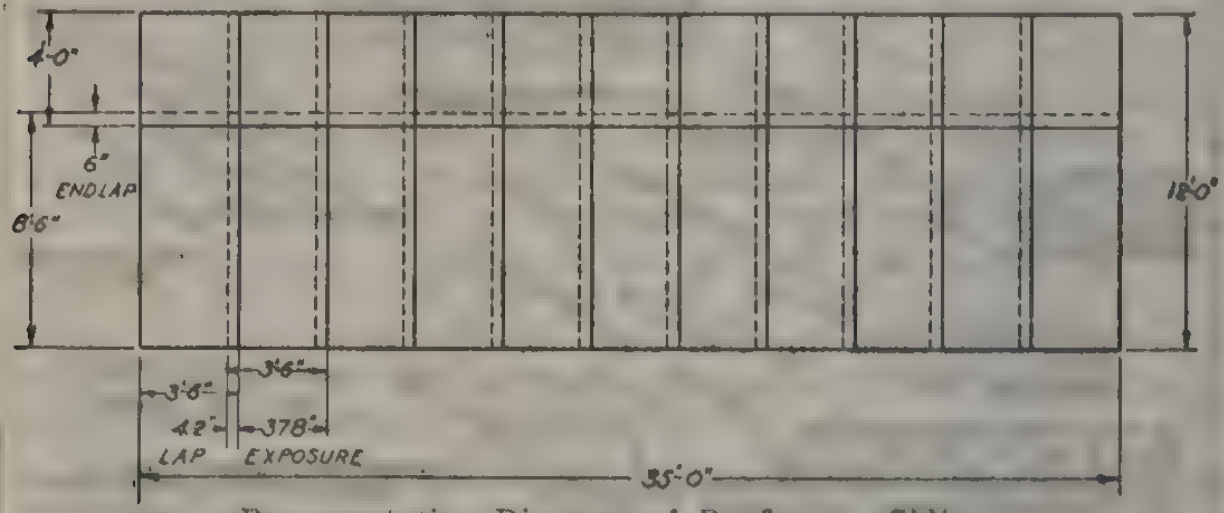
Erecting Corrugated Asbestos Roofing and Siding Using Straight Joint Construction.


FIRST SHEET OF THIRD COURSE OFFSET ONE CORRUGATION FROM FIRST SHEET OF SECOND COURSE TRIM OFF TWO CORRUGATIONS TO MAINTAIN UNIFORM RAKE LINE
SEE NOTE #1. ON THE ABOVE DRAWING
ONE CORRUGATION SIDE LAP
HORIZONTAL FASTENING 18" ON CENTERS
3"
6" END LAP
3"
ONE CORRUGATION SIDE LAP
FIRST SHEET OF SECOND COURSE OFFSET ONE CORRUGATION TO LEFT OF SHEET IMMEDIATELY BELOW TRIM OFF ONE CORRUGATION TO MAINTAIN UNIFORM RAKE LINE.
MAX. PURLIN SPACING * 4'-8"
MAX. GIRT SPACING 5'-8"
THE FIRST OR EAVE COURSE OF SHEETS SHOULD BE LAID TO A GUIDE LINE STRETCHED ALONG THE ENTIRE LENGTH OF THE BUILDING. THIS LINE TO BE PLACED AT A POINT CORRESPONDING TO THE EAVES OR OVERHANG OF THE ROOF
FASTENING APPROX. 12" O.C. AT EAVES AND OTHER EXPOSED POINTS
ONE CORRUGATION SIDE LAP
MIN. ROOF PITCH * 3" TO THE FOOT
STAGGERED JOINT CONSTRUCTION WITH SQUARE-CORNER SHEETS

Erecting Corrugated Asbestos Roofing and Siding Using Staggered Joint Construction.

fasteners shall be covered on weather side with asbestos roof putty.

The percentage of the area to be covered which is absorbed by the end and side laps of the corrugated asbestos sheets will vary with the length of that area and the number of courses of sheets required. Therefore, a rough general layout of sheets should be made and area of laps determined before any estimating figures are made. See illustration.



Representative Diagram of Roofing or Siding

Area of 10 side laps	(8'-6" + 4'-0") x 35'	= 43.75	sq. ft.
Area of 1 end lap	(35'-0" x .5)	= 17.5	sq. ft.
		61.25	sq. ft.
Area to be covered 12'-0" x 35'-0"		= 420.00	sq. ft.
Sq. ft. of corrugated asbestos roofing or siding required			481.25 sq. ft.

Approximate Prices of Corrugated Asbestos Roofing and Siding

Weight per Square Foot	Price per 100 Sq. Ft. of Roof or Siding Area
4.1 lb.	$36.00

Prices of Ridge, Corner Roll and Louver Blades

	Approx. Wt. Lin. Ft.	Price per Lin. Ft.
Ridge and corner roll, including battens, fasteners, and Transfalt strips	4 lbs.	$1.52
Louver blades	3.3 lbs.	.40

Fasteners for Asbestos Roofing and Siding

	Approx. Wt. 100 Sq. Ft.	Price per 100 Sq. Ft.
Lead headed fasteners (galv. iron) for use over wood framing	4 lbs.	$2.50
Lead headed fasteners (galv. iron) for use over steel framing	6 lbs.	4.50

Labor Handling and Placing Corrugated Asbestos Roofing and Siding.—The labor cost of handling and placing asbestos siding and roofing will vary according to the class of work, whether placed over wood or steel purlins or girts, size of sheets used and conditions under which the work is performed.

The most economical organization for applying asbestos roofing and siding consists of one mechanic, 2 helpers and 3 laborers, and the labor costs given on the following pages are computed on this basis. Local labor regulations may require all crew members to be mechanics, in which case apply journeyman's wage rate to all labor hours.

The labor costs include all time necessary cementing joints and covering exposed fasteners with asbestos roof putty, also the time necessary placing ridge roll, corner roll, louver blades, etc.

Placing Corrugated Asbestos Siding Over Wood Framing.—When placing asbestos siding in sheets 42"x48" to 42"x60" on wood framing, a crew consisting of mechanic, 2 helpers and 3 laborers should handle, place and fasten 7 to 8 sheets an hr. or 56 to 64 sheets per 8-hr. day. Inasmuch as the smaller sheets cover 11 sq. ft. minimum and the larger sheets 14 sq. ft. minimum, this is equivalent to 700 to 800 sq. ft. per 8-hr. day.

When placing corrugated sheets 42"x72" to 42"x96" on sidewalls, a crew should handle, place and fasten 6 to 7 sheets an hr. or 48 to 56 sheets per 8-hr. day. Inasmuch as the smaller sheets cover 17.3 sq. ft. minimum and the larger sheets 23.6 sq. ft. minimum, this is equivalent to 975 to 1,125 sq. ft. per 8-hr. day.

Placing Corrugated Asbestos Siding on Steel Framing.—When placing corrugated asbestos siding 42"x48" to 42"x60" on steel framing, a crew consisting of one mechanic, 2 helpers and 3 laborers should handle, place and fasten 5 to 6 sheets an hr. or 40 to 48 sheets containing 500 to 600 sq. ft., per 8-hr. day.

When placing sheets from 42"x72" to 42"x96" on sidewalls, an erection crew of 6 men should handle, place and fasten 4 to 5 sheets an hr. or 32 to 40 sheets containing 650 to 800 sq. ft., per 8-hr. day.

Placing Corrugated Asbestos Roofing Over Wood Purlins.—When placing corrugated sheets 42"x48" to 42"x60" on roofs over wood purlins, an erection crew consisting of a mechanic, 2 helpers and 3 laborers should handle, place and fasten 8 to 9 sheets an hr. or 64 to 72 sheets, containing 800 to 900 sq. ft., per 8-hr. day.

When placing sheets 42"x72" to 42"x96" over wood purlins, an erection crew should handle, place and fasten 7 to 8 sheets an hr. or 56 to 64 sheets, containing 1,150 to 1,300 sq. ft., per 8-hr. day.

Placing Corrugated Asbestos Roofing Over Steel Purlins.—When placing 42"x48" to 42"x60" corrugated asbestos roofing over steel purlins, an erection crew consisting of a mechanic, 2 helpers and 3 laborers should handle, place and fasten 7 to 8 sheets an hr. or 56 to 64 sheets, containing 700 to 800 sq. ft. per 8-hr. day.

When placing 42"x72" to 42"x96" sheets of corrugated asbestos roofing over steel purlins, an erection crew of 6 men should handle, place and fasten 6 to 7 sheets an hr. or 48 to 56 sheets, containing 950 to 1,100 sq. ft. per 8-hr. day.

Cost of 100 Sq. Ft. (1 Sq.) 42"x96"x$\frac{3}{8}$" Corrugated Asbestos Siding Over Wood Framing

	Hours	Rate	Total	Rate	Total
1 sq. corr. siding*.....		$.....	$.....	$36.00	$36.00
1 sq. (4 lbs.) fasteners....		.....	.....	2.50	2.50
Mechanic 0.75		.....	.....	7.00	5.25
Helper 1.50		.....	.....	5.00	7.50
Labor 2.25		.....	.....	5.00	11.25
Cost per 100 sq. ft.....4.50			$.....		$62.50†

If sheets 42"x48" to 42"x60" are used, add 0.3-hr. mechanic; 0.6-hr. helper and 0.9-hr. labor time per 100 sq. ft.

Cost of 100 Sq. Ft. (1 Sq.) 42"x96"x$\frac{3}{8}$" Corrugated Asbestos Siding Over Steel Framing

	Hours	Rate	Total	Rate	Total
1 sq. corr. siding*.....		$.....	$.....	$36.00	$36.00
1 sq. (6 lbs.) fasteners....		.....	.....	4.50	4.50
Mechanic 1.1		.....	.....	7.00	7.70
Helper 2.2		.....	.....	5.00	11.00
Labor 3.3		.....	.....	5.00	16.50
Cost per 100 sq. ft.... 6.6			$.....		$75.70†

If sheets 42"x48" to 42"x60" are used, add 0.4-hr. mechanic; 0.8-hr. helper and 1.2-hr. labor time per 100 sq. ft.

Cost of 100 Sq. Ft. (1 Sq.) 42"x96"x$\frac{3}{8}$" Corrugated Asbestos Roofing Over Wood Framing

	Hours	Rate	Total	Rate	Total
1 sq. corr. roofing*.....		$.....	$.....	$36.00	$36.00
1 sq. (4 lbs.) fasteners....		.....	.....	2.50	2.50
Mechanic 0.67		.....	.....	7.00	4.67
Helper 1.33		.....	.....	5.00	6.67
Labor 2.00		.....	.....	5.00	10.00
Cost per 100 sq. ft.....4.00			$.....		$59.84†

*Quantity varies with size of sheet. See Table Representative Diagram.
†If work is to be sublet, add for sub-contractors overhead and profit.

If sheets 42"x48" to 42"x60" are used, add 0.33-hr. mechanic; 0.67-hr. helper and 1 hr. labor time per 100 sq. ft.

Cost of 100 Sq. Ft. (1 Sq.) 42"x96"x⅛" Corrugated Asbestos Roofing Over Steel Framing

	Hours	Rate	Total	Rate	Total
1 sq. corr. roofing*		$.....	$.....	$36.00	$36.00
1 sq. (6 lbs.) fasteners		.....	.....	4.50	4.50
Mechanic	0.75	.....	.....	7.00	5.25
Helper	1.50	.....	.....	5.00	7.50
Labor	2.25	.....	.....	5.00	11.25
Cost per 100 sq. ft.	4.50		$.....		$64.50†

*Quantity varies with size of sheet. See Table Representative Diagram.
†If work is to be sublet, add for sub-contractors overhead and profit.

If sheets 42"x48" to 42"x60" are used, add 0.25-hr. mechanic; 0.50-hr. helper and 0.75-hr. labor time per 100 sq. ft.

BUILT-UP ROOFING

Built-up roofing consists of alternate plies of saturated felt and moppings of pitch with tar saturated felt or asphalt with asphalt saturated felt, covered with a top pouring of pitch or asphalt into which slag or gravel is embedded. On flat roofs with slopes of less than ¼" per foot, on which water may collect and stand, or on which water may be maintained for air conditioning purposes, coal tar pitch and felt or a low melting point asphalt bitumen and asphalt felt are generally used. Coal tar pitch is not recommended for roofs having an incline in excess of 1" per foot.

On built-up roofs, where slope is over 2" per foot up to 4" per foot, steep asphalt (180°-200° melting point) is more suitably used and slag is embedded in preference to gravel because it remains embedded better than well rounded gravel. Where slag is not available and where a light gray or white surface is desired, hard limestone chips, angular pieces ¼" to ¾" in size, are embedded in the top pouring of bitumen. On slopes over 2" per foot double coverage mineral surfaced roll roofing with a 19" selvage edge may be used as the top finish.

Smooth surface built-up roofing consists of alternate plies of asbestos felt cemented solid to the base sheet and to each other with asphalt, and a top coating of hot or cold asphalt, uniformly distributed.

A method for decreasing the peaks of heat in any type of building during the summer months is to install a spray mist system which cools the roof by evaporation. It permits the roof deck to be

designed with a slope and thus avoid the hazards of ponded water.

The specifications on the various types of roof vary widely, depending upon the surface to which the built-up roofing is applied and the service required.

The cost of a built-up roof is governed by the incline of the roof, size, plan (whether cut up with openings, skylights, pent houses, irregular roof levels, etc.), and the distance of the roof above the ground, as the higher the roof the higher materials must be hoisted, which increases the labor costs.

The rules for estimating quantities of built-up roofing are given in the first part of this chapter, under the heading "Rules for Measuring Flat Roofs."

Roofing Contractor's Overhead Expense and Profit.—The quantities and costs on composition roofing given on the following pages are actual and do not include any allowance for roofing contractor's overhead expense and profit.

A roofing contractor's overhead expense will probably run between 25 to 30 percent of the actual cost of the work, which includes workmen's compensation and public liability insurance, old age benefits, unemployment compensation taxes, as well as contributions to pension or welfare funds.

In addition, it will be necessary to add at least 10 percent for profit, making a total addition over actual cost of 35 to 40 percent.

The estimator should use his own judgment as to the amount to be added for overhead and profit—it varies a lot among different contractors.

Quantity of Pitch or Asphalt Required for Built-Up Roofs.—The quantity of roofing pitch or asphalt required for any built-up roof will vary with the number of thicknesses or plies of felt used. All manufacturers of roofing materials indicate in their specifications the amount of materials required for first class roof. On every first class roof plenty of pitch or asphalt is used in each mopping so that each ply of felt is well cemented to the next and in no instance does felt touch felt.

Approximately 25 lbs. of coal tar pitch or approximately 20 lbs. of asphalt should be used for each mopping per 100 sq. ft. of surface and the last pouring in which the gravel or slag is imbedded, should use 60 lbs. of asphalt or 75 lbs. of pitch per 100 sq. ft.

Quantity of asphalt required for 100 sq. ft. of roof.

Number Plies	Number of Plies Dry	Number of Plies Mopped	Surface to Which Roof is Applied	Lbs. per 100 Sq. Ft.
5	2	3	Wood, plywood, structural wood fiber	120
4	1	3	Poured gypsum, lightweight concrete	120
4		4	Concrete, precast concrete or gypsum	140

For roofing pitch add approximately 5 lbs. per mopping each ply per 100 sq. ft.—add 15 lbs. for top pouring per 100 sq. ft.

Estimating the Quantity of Roofing Felt.—Asphalt or tarred felt for built-up roofing is furnished in 4 sq. rolls containing 432 sq. ft. and weighing from 56 to 62 lbs. per roll for No. 15 felt. No. 30 felt which is generally used as the base sheet over wood construction when an asphalt specification is used is furnished in 2 sq. rolls containing 216 sq. ft. and weighing 60 lbs. These weights are those used on a bonded job in the best type of building construction.

When specifying the grade or weight of felt to be used it is customary to state that "felt shall weigh not less than 15 lbs. per 108 sq. ft." 15 lbs. per 108 sq. ft. is standard practice of all roofing manufacturers. Inasmuch as felt is furnished in 4 sq rolls of 432 sq. ft., 32 sq. ft. per roll or 8 sq. ft. per 100 sq. ft. allowed for laps.

The following table gives the quantity of roofing felt req. to cover 100 sq. ft. of surface of various thicknesses:

Number of Plies	Add for Waste	No. Sq. Ft. Req'd. 100 Sq. Ft. Roof	Weight per Square of Roof Using No. 15 Felt
1	8%	108	15
2	8%	216	30
3	8%	324	45
4	8%	432	60
5	8%	540	75

No. 30 felt is seldom used in more than 1-ply construction. The general use of No. 30 felt is as a base sheet over wood decks in 1-ply construction over which subsequent layers of No. 15 felts are mopped in.

Quantity of Roofing Gravel Required for Built-Up Roofs.—Roofing gravel should be uniformly embedded into a heavy top pouring of asphalt or pitch so that approximately 400 lbs. of gravel or 300 lbs. of slag is used per 100 sq. ft. of roof area.

Labor Applying Built-Up Roofing.—The labor cost of handling materials and applying built-up roofing will vary with the specification used and the type of building to which the roofing is applied. On the low type of building, 1, 2 or 3 stories high,

where there is no great distance from the ground to the roof deck, the labor for hoisting materials and supplying hot asphalt or pitch from the ground to the roof deck is considerably less than on a high building where there is a greater distance from the kettle to the roof.

On low type buildings, a 5-man crew composed of 1 man at the kettle, 1 man carrying 'hot stuff,' 1 man rolling in felts, 1 man nailing in and 1 man mopping in, can lay the following areas per 8-hr. day:

18 sqs. of 5-ply asphalt and gravel or pitch and gravel over wood roof deck, consisting of 1 sheathing paper, 2 dry felts and 3 plies of felt mopped in with a top pouring of pitch or asphalt and gravel surfacing.

18 sqs. of 4-ply asphalt and gravel or pitch and gravel over a concrete deck, all mopped including a top pouring of pitch or asphalt and gravel or slag surfacing.

22 sqs. of 4-ply asphalt and gravel or pitch and gravel over wood roof deck, consisting of 1 sheathing paper, 2 dry felts and 2 plies of felt mopped in with a top pouring of pitch or asphalt and gravel or slag surfacing.

22 sqs. of 3-ply asphalt and gravel or pitch and gravel over concrete roof deck, all mopped and including a top pouring of pitch or asphalt and gravel or slag surfacing.

The above figures apply to buildings up to 3 stories in height.

On buildings of considerable height or if the roof surfaces are broken up with skylights, irregular roof level, etc., the above quantities should be reduced about 25 per cent.

A 5-man crew should apply the following number of squares of roof per 8-hr. day, based on first class workmanship throughout:

Kind of Roof	Type "A" Structures	Type "B" Structures
3-ply roof over wood roof deck.....	24	18
3-ply roof over concrete roof deck.....	22	17
4-ply roof over wood roof deck.....	22	17
4-ply roof over concrete roof deck.....	18	14
5-ply roof over wood roof deck.....	18	14

Type "A" buildings are the most convenient type of structure for application of built-up roofing. A low type of building from 1 to 3 stories in height, straight, practically flat area not broken up by very many skylights or variations in the deck elevation.

Type "B" buildings are not convenient type of structures for the application of built-up roofing. These would include high

buildings which require considerable handling of materials, and buildings with roofs broken up by skylights or penthouses, saw-tooth construction, monitors, or considerable variation in deck levels.

On type "B" buildings more than three stories high, costs are decreased slightly if the roofer is permitted to heat the pitch or asphalt on the roof. Narrow kettles that will pass through doorways are available for such work.

An easy and accurate method of computing the labor cost on any type of roof is to take the cost of a 5-man crew for an 8-hr. day, and divide this by the number of squares of roof applied per day, as follows:

	Hours	Rate	Total	Rate	Total
Foreman	8	$.....	$.....	$6.75	$ 54.00
Roofers	32	.....	.....	6.25	200.00
Crew cost per 8-hr. day	40		$.....		$254.00
Cost per sq. 14 sqs. per day			.....		18.12
Cost per sq. 17 sqs. per day			.....		14.93
Cost per sq. 18 sqs. per day			.....		14.10
Cost per sq. 22 sqs. per day			.....		11.53
Cost per sq. 24 sqs. per day			.....		10.58

On the average roof where the mopping between layers consists of mopping the width of the lap, a roofer should mop 100 sq. ft. of surface in 6 to 7 minutes.

On first grade work where the entire roof surface is mopped between each layer of felt, a man should mop 100 sq. ft. of roof in about 10 minutes.

After the roof surface has been mopped, a roofer should place roofing felt over 100 sq. ft. in about 6 minutes.

Where first grade workmanship is required, a roofer should handle pitch and gravel, pour hot pitch or asphalt and spread gravel over one square of roof in 35 to 40 minutes.

Quantity of Materials Required for Built-Up Roofs.—The quantities of coal tar pitch, asphalt, felt, gravel, slag, etc., required for the various types are those recommended by various manufacturers.

Prices on Roofing Materials.—Prices on roofing materials such as coal tar pitch, asphalt, felt, etc., vary according to market fluctuations, location of job, etc. Current material prices should always be obtained, before submitting bid.

Cost of 100 Sq. Ft. (1 Sq.) 3-Ply Tar and Gravel Built-Up Roof Applied Over Wood Roof Deck

Maximum incline 2-in. per ft. One ply No. 30 felt, 2 plies No. 15 felt (1 dry, nailed and 2 mopped), coal tar pitch surfaced with gravel or slag.

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt.....		$.....	$.....	$2.20	$ 2.20
2 sq. rolls No. 15 felt.....		.....	.....	1.15	2.30
135 lbs. coal tar pitch.....		.....	.....	3.50	4.73
400 lbs. roofing gravel....		.....	.....	.25	1.00
Nails, fuel, mops, etc.....		.....	.....	.80	.80
Foreman 0.34		.....	.....	6.75	2.30
Roofer 1.36		.....	.....	6.25	8.51
Cost per 100 sq. ft.....1.70			$.....		$21.84

If applied to a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 3-Ply Tar and Gravel Built-Up Roof Over Poured Concrete and Poured Gypsum Roof Decks

Maximum incline 2-in. per ft. Roof consisting of 3 plies of felt, coal tar pitch surfaced with gravel or slag.

	Hours	Rate	Total	Rate	Total
3 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 3.45
165 lbs. coal tar pitch.....		.....	.....	3.50	5.78
400 lbs. roofing gravel....		.....	.....	.25	1.00
Nails, fuel, mops, etc.....		.....	.....	1.00	1.00
Foreman	0.36	.....	.....	6.75	2.43
Roofer	1.45	.....	.....	6.25	9.06
Cost per 100 sq. ft.....	1.81		$.....		$22.72

If applied to a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Tar and Gravel Built-Up Roof Applied Over Wood Roof Deck

Maximum incline 2-in. per ft. Roof consisting of 1 thickness of 5 lb. sheathing paper, 4 plies of felt (2 dry, nailed and 2 mopped), coal tar pitch surfaced with gravel or slag.

	Hours	Rate	Total	Rate	Total
1 sq. roll sheathing paper..		$.....	$.....	$0.80	$ 0.80
4 sq. rolls No. 15 felt.....		.....	.....	1.15	4.60
135 lbs. coal tar pitch.....		.....	.....	3.50	4.73
400 lbs. roofing gravel....		.....	.....	.25	1.00
Nails, fuel, mops, etc.....		.....	.....	.80	.80
Foreman	0.36	.....	.....	6.75	2.43
Roofer	1.45	.....	.....	6.25	9.06
Cost per 100 sq. ft.....	1.81		$.....		$23.42

If applied to a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Tar and Gravel Built-Up Roof Over Poured Concrete and Poured Gypsum Roof Deck

Maximum incline 2-in. per ft. Roof consisting of 4 plies of felt, coal tar pitch surfaced with gravel or slag.

	Hours	Rate	Total	Rate	Total
4 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 4.60
195 lbs. coal tar pitch.....		.....	.....	3.50	6.83
400 lbs. roofing gravel....		.....	.....	.25	1.00
Nails, fuel, mops, etc.....		.....	.....	1.20	1.20
Foreman	0.45	.....	.....	6.75	3.04
Roofer	1.80	.....	.....	6.25	11.25
Cost per 100 sq. ft.....	2.25		$.....		$27.92

If applied over a Type "B" roof, add 0.67-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 5-Ply Tar and Gravel Built-Up Roof Applied Over Wood Roof Deck

Maximum incline 2-in. per ft. Roof consisting of 1 thickness of 5 lb. sheathing paper, 5 plies of felt (2 dry, nailed and 3 mopped), coal tar pitch surfaced with gravel or slag.

	Hours	Rate	Total	Rate	Total
1 sq. roll sheathing paper..		$.....	$.....	$0.80	$ 0.80
5 sq. rolls No. 15 felt.....		.....	.....	1.15	5.75
165 lbs. coal tar pitch.....		.....	.....	3.50	5.78
400 lbs. roofing gravel....		.....	.....	.25	1.00
Nails, fuel, mops, etc.....		.....	.....	1.00	1.00
Foreman	0.45	.....	.....	6.75	3.04
Roofer	1.80	.....	.....	6.25	11.25
Cost per 100 sq. ft.....	2.25		$.....		$28.62

If applied to a Type "B" roof, add 0.7-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 5-Ply Built-Up Coal Tar Pitch Roof Applied Under Promenade Tile

For application over concrete deck on inclines up to 1-in. per ft.

	Hours	Rate	Total	Rate	Total
5 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 5.75
225 lbs. coal tar pitch.....		.....	.....	3.50	7.88
Fuel, mops, etc.		.....	.....	.95	.95
Foreman	0.57	.....	.....	6.75	3.85
Roofer	2.28	.....	.....	6.25	14.25
Cost per 100 sq. ft.....	2.85		$.....		$32.68

Cost of 100 Sq. Ft. (1 Sq.) 3-Ply Tar and Gravel Built-Up Roof Applied Over Precast Concrete Slab Decks

Maximum incline 2-in. per ft. Roof consisting of 3 plies of saturated felt, coal tar pitch surfaced with gravel or slag.

	Hours	Rate	Total	Rate	Total
3 sq. rolls No. 15 felt		$.....	$.....	$1.15	$ 3.45
165 lbs. pitch		.....	.....	3.50	5.78
Nails, fuel, mops, etc.		.....	.....	1.00	1.00
400 lbs. gravel		.....	.....	.25	1.00
Foreman	0.4	.....	.....	6.75	2.70
Roofer	1.4	.....	.....	6.25	8.75
Cost per 100 sq. ft.	1.8		$.....		$22.68

If applied over a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Tar and Gravel Built-Up Roof Applied Over Precast Concrete Slab Decks

Maximum incline 2-in. per ft. Roof consisting of 4 plies of saturated felt, coal tar pitch surfaced with gravel or slag.

	Hours	Rate	Total	Rate	Total
4 sq. rolls No. 15 felt		$.....	$.....	$1.15	$ 4.60
195 lbs. pitch		.....	.....	3.50	6.83
Nails		.....	.....	.50	.50
400 lbs. gravel		.....	.....	.25	1.00
Fuel, mops, etc.		.....	.....	.80	.80
Foreman	0.4	.....	.....	6.75	2.70
Roofer	1.8	.....	.....	6.25	11.25
Cost per 100 sq. ft.	2.2		$.....		$27.68

If applied over a Type "B" roof, add 0.6-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Tar and Gravel Built-Up Roof Applied Over Precast Gypsum or Gypsum Steel Plank Decks

Maximum incline 2-in. per ft. Roof consisting of 4 plies of saturated felt (2 dry, nailed; 2 mopped), coal tar pitch surfaced with gravel or slag.

	Hours	Rate	Total	Rate	Total
4 sq. rolls No. 15 felt		$.....	$.....	$1.15	$ 4.60
135 lbs. pitch		.....	.....	3.50	4.73
Nails, fuel, mops, etc.		.....	.....	.80	.80
400 lbs. gravel		.....	.....	.25	1.00
Foreman	0.4	.....	.....	6.75	2.70
Roofer	1.8	.....	.....	6.25	11.25
Cost per 100 sq. ft.	2.2		$.....		$25.08

If applied over a Type "B" roof, add 0.6-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 5-Ply Tar and Gravel Built-Up Roof Applied Over Precast Gypsum or Gypsum Steel Plank Decks

Maximum incline 2-in. per ft. Roof consisting of 5 plies of saturated felt (2 dry, nailed, 3 mopped), coal tar pitch surfaced with tar or gravel.

	Hours	Rate	Total	Rate	Total
5 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 5.75
165 lbs. pitch.....		.....	.....	3.50	5.78
Nails, fuel, mops, etc.....		.....	.....	1.00	1.00
400 lbs. gravel		.....	.....	.25	1.00
Foreman	0.5	.....	.....	6.75	3.38
Roofer	2.1	.....	.....	6.25	13.13
Cost per 100 sq. ft.	2.6		$.....		$30.04

If applied over a Type "B" roof, add 0.6-hr roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 3-Ply Tar and Gravel Built-Up Roof Applied Over Steel Roof Deck With Insulation

Max. incline 1-in. per ft. 3 plies sat. felt, coal tar pitch, gravel or slag.

	Hours	Rate	Total	Rate	Total
3 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 3.45
25 lbs. steep asphalt.....		.....	.....	3.20	.80
165 lbs. pitch*.....		.....	.....	3.50	5.78
400 lbs. gravel		.....	.....	.25	1.00
Fuel, mops, etc.		.....	.....	.75	.75
Foreman 0.36		.....	.....	6.75	2.43
Roofer 1.44		.....	.....	6.25	9.00
Cost per 100 sq. ft.	1.80		$.....		$23.21

If applied over a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Tar and Gravel Built-Up Roof Applied Over Steel Roof Deck With Insulation

Max. incline 1-in. per ft. 4 plies sat. felt, coal tar pitch, gravel or slag.

	Hours	Rate	Total	Rate	Total
4 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 4.60
25 lbs. steep asphalt.....		.....	.....	3.20	.80
195 lbs. pitch*.....		.....	.....	3.50	6.83
400 lbs. gravel		.....	.....	.25	1.00
Fuel, mops, etc.		.....	.....	.95	.95
Foreman 0.45		.....	.....	6.75	3.04
Roofer 1.80		.....	.....	6.25	11.25
Cost per 100 sq. ft.....2.25			$.....		$28.47

*When more than one layer of insulation is installed and pitch is mopped between layers, add 30 lbs. per square for each mopping.

STEEP ROOFS

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Slag Surface Built-Up Roof Applied Over Steep Wood Roof Deck

Maximum incline 4 in. per ft. Minimum incline 2 in. per ft. One thickness 5 lb. sheathing paper, 4 plies tarred felt, nailed through flat tin discs and mopped. Slag surfaced.

	Hours	Rate	Total	Rate	Total
1 sq. roll sheathing paper..		$.....	$.....	$0.80	$ 0.80
4 sq. rolls No. 15 felt.....		.....	.....	1.15	4.60
135 lbs. steep pitch.....		.....	.....	3.20	4.32
Nails, discs, fuel, mops, etc.		.....	.....	1.50	1.50
275 lbs. slag.....		.....	.....	.30	.83
Foreman 0.45		.....	.....	6.75	3.04
Roofer 1.80		.....	.....	6.25	11.25
Cost per 100 sq. ft.....2.25			$.....		$26.34

If applied to a Type "B" Roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 5-Ply Slag Surface Built-Up Roof Applied Over Steep Wood Roof Deck

Maximum incline 4 in. per ft. Minimum incline 2 in. per ft. Roof of 1 thickness 5 lb. sheathing paper, 5 plies tarred felt, nailed through flat tin discs and mopped. Slag surfaced.

	Hours	Rate	Total	Rate	Total
1 sq. roll sheathing paper..		$.....	$.....	$0.80	$ 0.80
5 sq. rolls No. 15 felt.....		.....	.....	1.15	5.75
160 lbs. steep pitch.....		.....	.....	3.20	5.12
275 lbs. slag.....		.....	.....	.30	.83
Nails, discs, fuel, mops, etc.		.....	.....	1.65	1.65
Foreman 0.55		.....	.....	6.75	3.72
Roofer 2.15		.....	.....	6.25	13.44
Cost per 100 sq. ft. 2.70			$.....		$31.31

If applied to a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 2-Ply Mineral Surface Built-Up Roof Applied Over Steep Wood Roof Deck

Maximum incline 9 in. per ft. Minimum incline 2 in. per ft. Roof consisting of 1 thickness of No. 30 felt and 1 thickness of selvage-edge mineral surface roofing, nailed through flat tin discs and mopped at laps.

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 30 felt		$.....	$.....	$2.20	$ 2.20
1 sq. min. surf. rfg.		.....	.....	4.80	4.80
50 lbs. steep asphalt		.....	.....	3.20	1.60
36 lbs. rfg. cement		.....	.....	5.00	1.80
Nails, discs, fuel, mops, etc.		.....	.....	1.20	1.20
Foreman	0.33	.....	.....	6.75	2.25
Roofer	1.32	.....	.....	6.25	8.44
Cost per 100 sq. ft.	1.65		$.....		$22.29

If applied to a Type "B" Roof, add 0.4-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 3-Ply Mineral Surface Built-Up Roof Applied Over Steep Wood Roof Deck

Maximum incline 9 in. per ft. Minimum incline 2 in. per ft. Roof consisting of 1 layer 5 lb. sheathing paper, 2 thicknesses of No. 15 felt and 1 thickness of selvage-edge mineral surface roofing, nailed through flat tin discs and mopped at laps.

	Hours	Rate	Total	Rate	Total
1 sq. roll sheathing paper		$.....	$.....	$0.80	$ 0.80
2 sq. rolls No. 15 felt		.....	.....	1.15	2.30
1 sq. min. surf. rfg.		.....	.....	4.80	4.80
75 lbs. steep asphalt		.....	.....	3.20	2.40
48 lbs. rfg. cement		.....	.....	5.00	2.40
Nails, discs, fuel, mops, etc.		.....	.....	1.25	1.25
Foreman	0.36	.....	.....	6.75	2.43
Roofer	1.44	.....	.....	6.25	9.00
Cost per 100 sq. ft.	1.80		$.....		$25.38

Cost of 100 Sq. Ft. (1 Sq.) 3-Ply Slag Surface Built-Up Roof Applied to Steep Poured Concrete or Poured Gypsum Roof Deck

Maximum incline 4 in. per ft. Minimum incline 2 in. per ft. Roof consisting of 3 plies No. 15 felt, nailed and mopped. Surfaced with slag.

	Hours	Rate	Total	Rate	Total
3 sq. rolls No. 15 felt		$.....	$.....	$1.15	$ 3.45
140 lbs. steep pitch		.....	.....	3.20	4.48
275 lbs. slag		.....	.....	.30	.83
Nails, discs, fuel, mops, etc.		.....	.....	1.40	1.40
Foreman	0.45	.....	.....	6.75	3.04
Roofer	1.80	.....	.....	6.25	11.25
Cost per 100 sq. ft.	2.25		$.....		$24.45

If applied over a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Slag Surface Built-Up Roof Applied to Steep Poured Concrete or Poured Gypsum Roof Deck

Maximum incline 4 in. per ft. Minimum incline 2 in. per ft. Roof consisting of 4 plies No. 15 felt, nailed and mopped. Surfaced with slag.

	Hours	Rate	Total	Rate	Total
4 sq. rolls No. 15 felt		$	$	$1.15	$ 4.60
165 lbs. steep pitch				3.20	5.28
275 lbs. slag				.30	.83
Nails, discs, fuel, mops, etc.				1.60	1.60
Foreman	0.5			6.75	3.38
Roofer	2.0			6.25	12.50
Cost per 100 sq. ft.	2.5		$		$28.19

If applied over a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 2-Ply Mineral Surface Roof Applied Over Steep Poured Concrete Deck

Maximum incline 9 in. per ft. Minimum incline 2 in. per ft. Roof consisting of 1 ply of No. 15 felt and 1 ply selvage-edge mineral surface roofing, nailed and mopped.

	Hours	Rate	Total	Rate	Total
1 gal. asphalt primer		$	$	$1.20	$ 1.20
1 sq. roll No. 15 felt				1.15	1.15
1 sq. min surf. rfg.				4.80	4.80
75 lbs. steep asphalt				3.20	2.40
42 lbs. rfg. cement				5.00	2.10
Nails, discs, fuel, mops, etc.				1.20	1.20
Foreman	0.36			6.75	2.43
Roofer	1.44			6.25	9.00
Cost per 100 sq. ft.	1.80		$		$24.28

If applied over a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 3-Ply Mineral Surface Roof Applied Over Steep Poured Gypsum Deck

Maximum incline 9 in. per ft. Minimum incline 2 in. per ft. Roof consisting of 2 plies No. 15 felt and 1 ply selvage-edge mineral surface roofing, nailed and mopped.

	Hours	Rate	Total	Rate	Total
1 gal. asphalt primer		$	$	$1.20	$ 1.20
2 sq. rolls No. 15 felt				1.15	2.30
1 sq. min. surf. rfg.				4.80	4.80
85 lbs. steep asphalt				3.20	2.72
48 lbs. rfg. cement				5.00	2.40
Nails, discs, fuel, mops, etc.				1.30	1.30
Foreman	0.45			6.75	3.04
Roofer	1.80			6.25	11.25
Cost per 100 sq. ft.	2.25		$		$29.01

If applied over a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Slag Surface Built-Up Roof Applied to Steep Precast Nailable Plank

Maximum incline 4 in. per ft. Minimum incline 2 in. per ft. Roof consisting of 4 plies of No. 15 felt, nailed between plies and mopped. Slag surface.

	Hours	Rate	Total	Rate	Total
4 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 4.60
135 lbs. steep pitch.....		.....	.....	3.20	4.32
275 lbs. slag		.....	.....	.30	.83
Nails, discs, fuel, mops, etc.		.....	.....	1.60	1.60
Foreman	0.5	.....	.....	6.75	3.38
Roofer	2.0	.....	.....	6.25	12.50
Cost per 100 sq. ft.....	2.5		$.....		$27.23

If applied to a Type "B" roof, add 0.5-hr. roofer time.

Cost of 100 Sq. Ft. (1 Sq.) 3-Ply Mineral Surface Roof Applied to Steep Precast Nailable Plank

Maximum incline 9 in. per ft. Minimum incline 2 in. per ft. Roof consisting of 2-plies No. 15 felt, nailed and mopped and 1-ply min. surf. rfg.

	Hours	Rate	Total	Rate	Total
2 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 2.30
1 sq. min. surf. rfg.....		.....	.....	4.80	4.80
75 lbs. steep asphalt.....		.....	.....	3.20	2.40
48 lbs. rfg. cement		.....	.....	5.00	2.40
Nails, discs, fuel, mops, etc.		.....	.....	1.20	1.20
Foreman	0.45	.....	.....	6.75	3.04
Roofer	1.80	.....	.....	6.25	11.25
Cost per 100 sq. ft.....	2.25		$.....		$27.39

If applied to a Type "B" roof, add 0.5-hr. roofer time.

WATER COOLED ROOFS

A roof deck intended for spray pond or water cooling is preferably dead level, but may have a slight incline providing that such slope does not exceed 1 inch per foot.

Cost of 100 Sq. Ft. (1 Sq.) 4-Ply Tar and Gravel Built-Up Spray Pond or Water Cooled Roof Applied Over Poured Concrete, Poured Gypsum or Precast Concrete Slab

Maximum incline $\frac{1}{8}$ in. per ft. Preferably dead level. Roof consisting of 4 plies of No. 15 felt, 2 applications of hot pitch and gravel or slag.

	Hours	Rate	Total	Rate	Total
4 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 4.60
270 lbs. pitch.....		.....	.....	3.50	9.45
700 lbs. gravel.....		.....	.....	.25	1.75
Fuel, mops, etc.		.....	.....	1.00	1.00
Foreman	0.5	.....	.....	6.75	3.38
Roofer	2.0	.....	.....	6.25	12.50
Cost per 100 sq. ft.....	2.5		$.....		$32.68

Cost of Recoating 100 Sq. Ft. (1 Sq.) Built-Up Roofing With Coal Tar Pitch

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$1.15	$ 1.15
75 lbs. coal tar pitch.....		.....	.....	3.50	2.63
250 lbs. roofing gravel....		.....	.....	.25	.63
Nails, fuel, mops, etc.....		.....	.....	1.00	1.00
Foreman	0.2	.....	.....	6.75	1.35
Roofer	0.8	.....	.....	6.25	5.00
Cost per 100 sq. ft.....	1.0		$.....		$11.76

Cost of 100 Sq. Ft. (1 Sq.) One Layer of Fiberboard Insulation Over Wood Roof Deck

Apply 1 layer of sheathing paper nailed in place. Over sheathing paper lay sheets of insulation in broken joint construction, nailing each sheet of insulation along the edges and through the center on 12-in. centers. Where more than one layer of insulation is used each layer should break all joints with previous layer and should be nailed through the top layer down into deck at least 1-in.

	Hours	Rate	Total	Rate	Total
1 sq. roll sheathing paper..		$.....	$.....	$0.80	$ 0.80
100 sq. ft. ½" insul. board		.....	.....	.10	10.00
Nails, ...		.....	.....	.80	.80
Roofer	0.6	.....	.....	6.25	3.75
Cost per 100 sq. ft.....	0.6		$.....		$15.35

Where humid conditions exist in the building, apply 2 layers of No. 15 saturated felt laid dry and nailed sufficiently to form a vapor barrier. Laps should be sealed with asphalt. Insulation should be mopped solidly to the No. 15 felt with roofing asphalt. Where more than one layer of insulation is used each layer should break all joints with previous layer and should be mopped solidly to the previous layer.

	Hours	Rate	Total	Rate	Total
1 sq. roll sheathing paper..		$.....	$.....	$0.80	$ 0.80
2 sq. rolls No. 15 felt.....		.....	.....	1.15	2.30
30 lbs. roofing asphalt....		.....	.....	3.20	.96
100 sq. ft. ½" insul. board		.....	.....	.10	10.00
Nails, fuel, mops, etc.....		.....	.....	1.00	1.00
Roofer	0.8	.....	.....	6.25	5.00
Cost per 100 sq. ft.....	0.8		$.....		$20.06

For each additional layer of insulation, add as follows per 100 sq. ft.:

Cost of 100 Sq. Ft. (1 Sq.) of Fiberboard Insulation Applied Over Non-Combustible Decks

Apply a heavy mopping of asphalt or pitch into which embed insulation in broken joint construction. On inclines over 3-in. per foot, insulation should be clipped to steel deck.

	Hours	Rate	Total	Rate	Total
30 lbs. roofing asphalt....		$.....	$.....	$3.20	$ 0.96
100 sq. ft. ½" insul. board		.....	.....	.10	10.00
Nails		.....	.....	.70	.70
Fuel, mops, etc.		.....	.....	.25	.25
Roofer	0.8	.....	.....	6.25	5.00
Cost per 100 sq. ft.	0.8		$.....		$16.91

Where humid conditions exist in the building, over the primed deck apply a heavy mopping of roofing asphalt and embed 2 layers of No. 15 saturated felt, cemented solidly in place. Insulation should be mopped solidly to the No. 15 felt with roofing asphalt.

	Hours	Rate	Total	Rate	Total
2 sq. rolls No. 15 felt.....		$.....	$.....	$1.15	$ 2.30
60 lbs. roofing asphalt....		.....	.....	3.20	1.92
100 sq. ft. ½" insul. board		.....	.....	.10	10.00
Fuel, mops, etc.		.....	.....	.40	.40
Roofer	1.1	.....	.....	6.25	6.88
Cost per 100 sq. ft.....	1.1		$.....		$21.50

For board thicker than given above, add difference in cost of board.

READY-TO-LAY ROOFING

Ready roofing is extensively used on all types of buildings where an inexpensive, yet satisfactory, roofing is required. It is furnished in various grades and weights and is sold by the roll or in flat sheets packed with the nails and cement necessary for application.

Laying Ready-to-Lay Roll Roofing.—When laying ready-to-lay roll roofing, a man should handle, lay and cement or nail in place about 600 to 800 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft. (1 sq.):

	Hours	Rate	Total	Rate	Total
Carpenter	1.2	$.....	$.....	$6.75	$8.10

Asphalt Slate Surfaced Ready-to-Lay Roofing

A ready-to-lay roofing consisting of several plies of asphalt impregnated felt, surfaced with a thick layer of slate granules, either red or green. For roofs having a pitch of 1½" or more per foot.

Furnished in rolls 36″ wide and 36′-0″ long, containing 108 sq. ft., sufficient for 100 sq. ft. of roof, at the following price per 90 lb. roll.....$4.10

Smooth Surfaced Ready-to-Lay Roofing

Mica surface asphalt roofing consisting of good quality felt saturated with pure asphalt and both sides covered with flake mica. Rolls 36″ wide and 36′-0″ long.

Description	Weight per roll	No. Sq. Ft. in Roll	Price per Roll
Mica surfaced asphalt roofing..	45 lbs.	108	$2.40
Mica surfaced asphalt roofing..	55 lbs.	108	2.80
Mica surfaced asphalt roofing..	65 lbs.	108	3.20

Approximate Prices on Insulating Board

FIBERBOARD

Thickness	Price Per Sq. Ft.
1″	$0.08
2″	.16

FOAMGLASS

Thickness	Price
2″	$0.30

FIBERGLASS

Thickness	Price
¾″	$0.08
1″	.12
2″	.24

POLYSTYRENE

Thickness	Price
1″	$0.11
2″	.12

CHAPTER XXII

INTERIOR MARBLE AND STRUCTURAL SLATE

To prepare an accurate estimate on cost of marble work, the estimator should understand the correct method of measuring and listing quantities from the plans; the manner in which the marble should be handled and set on the job, as well as the most economical and practical methods of handling the work.

When estimating marble wainscoting, it is incorrect to take the height of the wainscot from the floor to the cap and multiply by the number of lin. ft. because in all probability the wainscot is made up of three members, viz., base, die and cap, and each member should be estimated separately; the base and cap by the lin. ft. and the die by the square or superficial foot.

The length and size of the pieces of marble has considerable bearing on the labor cost, because it usually costs as much to set a 6″ piece as one 2′-0″ long, so that a job made up of short pieces will cost more per foot than a job having a larger percentage of long pieces of marble.

Trade Practice.—Trade practice in the marble industry recognizes all marbles and stones commonly used for interior building purposes, as falling within one of four groups or Classifications, according to their respective characteristics and working qualities. Therefore, for purposes of standardization and clearer definition, the National Association of Marble Dealers has officially adopted these four classifications and defines them as follows:

Group "A". Sound marbles and stones which require no "sticking," "waxing," or "filling;" characteristically uniform and favorable working qualities.

Group "B". Marbles and stones similar in character to the preceding group but somewhat less favorable working qualities; occasional natural faults and requiring a limited amount of "waxing" and "sticking."

Group "C". Marbles of uncertain variation in working qualities, geological flaws, voids, veins and lines of separation common; common shop practice to repair nature's shortcomings by sticking, waxing and filling; "liners" and other forms of reinforcement freely employed when necessary.

Group "D". Marbles and stones similar to the preceding group and subject to the same methods of finishing and manufacture but embracing those materials which contain a larger proportion of natural faults and a maximum variation in working qualities, etc. This group comprises many of the highly colored marbles prized for their decorative qualities.

Below is a list of some of the more commonly used varieties of marbles and stones and the groups to which they belong:

Group "A"

Alabama—usual grades
Blanco P
Brocadillo, Vermont
Carthage
Georgia
Italian White
Italian English Vein
Napoleon Gray (Vt.)
Tennessee, Gray and Pink
Vermont, Black
Vermont, White Grades
Vermont Pavonazzo
Westland Green Vein Cream

Group "B"

Alabama Cream Veined A
Belgian Black
Champville
Cremo Italian
Imperial Black, Tenn.
Mankato Buff
Travertine (Italian)

Group "C"

Belgian Grand Antique
Bois Jourdan
Botticino
Breche Opal
Escalette
Hauteville
Mankato Pink
Ozark Rouge
Red Levanto
Red Verona
Rosato
Tavernelle, all types
Verdona
Verona, Yellow
Vermont Verde Antique
Westfield Green

Group "D"

Alps Green
Black and Gold
Bleu Belge
Breche Oriental
Breche Rosora
Forest Green
Grand Antique, French
Grand Antique, Italian
Onyx, Pedrara
Rouge Antique
Rouge Jascolin
Sienna
Verde Antico (Italian)
Vert St. Denis

Estimating Quantities of Marble Work.—When measuring and listing quantities of marble work from the plans, there are several general rules that should be followed to insure accuracy.

To estimate accurately the quantity of marble base, obtain the number of lineal feet of base, listing the various heights separately. All base under 1'-0" high is extended and priced on a lineal foot basis. All base 1'-0" or over is extended and priced on a superficial foot basis. Always bear in mind that no piece of marble should be figured as being less than 1'-0" long, as it requires just as much time to set a 6" piece as one 2'-0" long. Short pieces are usually found around pilasters, door and window returns, etc.

Marble die is estimated by the square or superficial foot, and the labor costs computed in the same manner. When listing quantities, obtain the length of each run and multiply by the height, and the result will be the number of sq. ft. of die. If marble pilasters project beyond the face of the wall, list each projection according to its actual dimensions and if less than a 6" projection, it should be priced as 6" wide, but if the pilasters are over 6" wide, then use actual dimensions.

Marble wainscot cap under 1'-0" wide or any marble under 1'-0" wide, should be measured by the lineal foot.

Marble stair treads should be measured by the square or superficial foot, as they are ordinarily 12" or more in width, Be sure to mention length, width and thickness of all treads, type of nosing, etc.

Marble stair risers should be estimated by the lin. ft. giving length, height and thickness of each riser, as it costs practically as much to set a short riser as a long one.

When estimating toilet stall work consisting of toilet backs, partitions, stall fronts, stiles, etc., the fronts should be estimated by the superficial foot if over 12" wide and by the lin. ft. if less than 12" wide. Partitions and backs should be estimated by the superficial front. Marble cap is usually estimated by the lin. ft. Some marble contractors figure toilet work at a certain price per stall, including all labor in connection with same, although most contractors recommend pricing on a square or lineal foot basis. Prefabricated marble stalls are available ready for installation where job conditions are suitable to accommodate these units.

Marble column bases and caps formed of solid stock over 2" thick, should be estimated at a certain price for each base or cap, mentioning the size and number of cu. ft. in each.

Marble floor tile and border are usually estimated by the superficial foot, giving size of tile, such as 6"x6", 9"x9", 12"x12", etc. Small or irregular sized tile, such as dots, etc., are esti-

mated in the same manner, except that a notation should be made of the class of work, as it costs more to lay small and irregular shaped tile.

Marble handrail, moldings, etc., should be estimated by the lin. ft., giving the size of each, in order that the quantities may also be stated in cu. ft. if over 2" thick.

All classes of circular work, such as base, wainscot or die, should be estimated in the same units as straight work, except that circular work should be estimated separately, as it usually requires considerable more cutting and fitting than straight work.

All marble work cut and set "on the rake", such as stair wainscoting, wainscoting under stairs, etc., should be estimated by the superficial foot, using the largest dimensions. Work of this kind should be estimated separately as it is more expensive to set than straight work.

Handling and Setting Interior Marble.—Estimating the labor cost of handling and setting interior marble will depend as much upon the conditions under which the work is performed as any other class of construction work. The amount of labor handling, sorting and distributing the marble on the job before it is set should be considered, also whether it is necessary to hoist the marble above the first floor, as this will require considerably more handling. The average size of the pieces should be considered, such as the average length of base, size and thickness of wainscot, length of thresholds, treads, risers, caps, etc., as it costs almost as much to handle and set a short piece of marble as a long one. This is especially true on stock that can be handled by one man.

The labor costs given on the following pages are based on the performance of the regular crew of any well organized marble company but if it is necessary to hire "extra" men or "floaters", the daily production may be decreased 25 percent and the labor costs increased accordingly.

On practically all jobs it is necessary to have laborers handle the marble and distribute it ready for the setters, although in the larger cities all marble must be handled by marble setters and helpers. On large jobs a contractor may employ a "chain gang" composed of union helpers to handle the marble in the building. These men unload the marble from the cars or trucks, unpack and store it in the building or distribute it to the location in the building where it is to be used.

Hoisting Marble.—The proposal sheet of practically all marble contractors states that the marble contractor shall have free use of the general contractor's hoisting facilities, runways, etc., so for this reason no allowance has been made for hoisting in the following estimates of cost.

However, if it is necessary for the marble contractor to pay for the use of hoist for hoisting marble to the upper floors of a building, figure about ½-hr. hoist time per 100 sq. ft. of marble.

Trucking on Marble From Mill or Cars to Job.—If the marble is furnished by an out of town mill and it is necessary to haul it in trucks from cars to the job, the cost will vary with the length of the haul but under average conditions should not exceed 7 to 10 cts. per sq. ft. If the marble is furnished by a mill located in the same town as the job, the price of the marble will probably include delivery to the job.

Marble Contractor's Overhead Expense and Profit.—It is necessary to have a foreman on all jobs of any size to supervise the arrival, unloading and distribution of the stock, as well as to lay out the work and supervise the setting. On an average allow $\frac{1}{16}$ to ⅛-hr. foreman time to each hour setter's time, depending upon the size of the job and the number of setters employed.

Most small jobs will not require a foreman and no allowance should be made for same.

In addition to the wages of marble setters, it is necessary to allow a certain amount for union welfare or pension fund contributions, etc., which should be added to the hourly wage scale, if possible to do so, also allowance for paid holidays, etc.

It will also be necessary to allow for overhead expense, such as liability and workmen's compensation insurance, office and traveling expense, profit, etc., which will vary according to the size of the job.

A fair allowance for overhead expense and profit is 40 to 50% of the actual cost of the work.

Average Labor Cost Setting Interior Marble.—While the labor cost of marble setting will vary with the kind of material handled, some of the large producing marble companies estimate the setting cost of the entire job at a certain price per foot.

The quantities for the entire job are taken, which include base, cap, wainscot or die, treads, risers, etc., and the labor priced at $1.90 to $2.50 per sq. ft., or 100 sq. ft. should cost as follows:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	12.0	.....	.....	6.50	78.00
Helper	12.0	.....	.....	5.00	60.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 sq. ft.	33.5		$.....		$188.50*
Cost per sq. ft.					1.89

The above price includes setting on jobs consisting principally of ⅞" and 1¼" stock.

If 2" marble is used, the handling and setting cost will be increased considerably, and the labor per 100 sq. ft. should cost as follows:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	16.0	.....	.....	6.50	104.00
Helper	16.0	.....	.....	5.00	80.00
Labor or helper	12.0	.....	.....	5.00	60.00
Cost 100 sq. ft.	45.5		$.....		$254.50*
Cost per sq. ft.			.....		2.55

Average setting cost for both ⅞" and 2" stock about $2.20 per sq. ft. at above rates.

On jobs having an average amount of base, wainscot or die, cap, toilet stalls, treads and risers, etc., the above prices will prove close enough, but where there are large quantities of any one class of work, it is advisable to refer to that particular class of work to obtain accurate quantities and costs.

Setting Marble Base.—The cost of setting marble base will vary with the size of the rooms, whether straight walls or broken up with pilasters, piers, etc., and whether the job consists of long or short pieces of base.

In small corridors and other spaces having numerous pilasters, piers, etc., requiring short pieces of base, a setter and helper should set 60 to 75 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	.....	.....	$7.00	$ 10.50
Marble setter	12.0	$.....	$.....	6.50	78.00
Helper	12.0	.....	.....	5.00	60.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 lin. ft.	33.5		$.....		$188.50*
Cost per lin. ft.					1.89

If the base can be set in reasonably long pieces, a marble setter and helper should set 80 to 100 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

*Add for overhead and profit.

	Hours	Rate	Total	Rate	Total
Foreman	1	$.....	$.....	$7.00	$ 7.00
Marble setter	9	.....	.....	6.50	58.50
Helper	9	.....	.....	5.00	45.00
Labor or helper	8	.....	.....	5.00	40.00
Cost 100 lin. ft.	27		$.....		$150.00*
Cost per lin. ft.			.....		1.50

Setting Circular Base.—Setting circular base will run about double the cost of straight work of the same kind and set under similar conditions. There is usually considerable cutting and fitting on all circular work.

Setting Marble Wainscot or Die.—The labor cost of setting marble wainscot or die will vary with the size of the pieces, the height of the wainscot or die, etc., as a marble setter will set almost as many lin. ft. of 5′-0″ wainscot as 3′-0″ wainscot. The labor cost handling stock will be increased somewhat, as it will require 2 to 4 laborers or helpers to handle each piece of marble and place it on the floor ready for the setter, while lighter stock, such as base, risers, treads, etc., can be handled by one man.

Setting Marble Wainscot Up to 3′-0″ High.—When setting marble wainscot up to 3′-0″ high, a marble setter and helper should set 22 to 26 lin. ft. containing 66 to 78 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	11.0	.....	.....	6.50	71.50
Helper	11.0	.....	.....	5.00	55.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 sq. ft.	31.5		$.....		$177.00*
Cost per sq. ft.			.....		1.77

The cost of setting circular wainscot or die will run about double the cost of straight work on account of the extra cutting and fitting.

Setting Marble Wainscot 3′-0″ to 4′-0″ High.—A marble setter and helper should set 20 to 25 lin. ft. containing 75 to 90 sq. ft. of wainscot per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.2	$.....	$.....	$7.00	$ 8.40
Marble setter	10.0	.....	.....	6.50	65.00
Helper	10.0	.....	.....	5.00	50.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 sq. ft.	29.2		$.....		$163.40*
Cost per sq. ft.			.....		1.63

*Add for overhead and profit.

The cost of setting circular wainscot or die will run about double the cost of straight work on account of the extra cutting and fitting.

Setting Marble Wainscot 4'-0" to 5'-0" High.—Where the marble wainscot varies from 4'-0" to 5'-0" high, a marble setter and helper should set 20 to 23 lin. ft. containing 85 to 100 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1	$.....	$.....	$7.00	$ 7.00
Marble setter	9	.....	.....	6.50	58.50
Helper	9	.....	.....	5.00	45.00
Labor or helper	8	.....	.....	5.00	40.00
Cost 100 sq. ft.	27	.....	$.....		$150.50*
Cost per sq. ft.			.....		1.51

The cost of setting circular wainscot or die will run about double the cost of straight work on account of the extra cutting and fitting.

Setting Marble Wainscot Over 5'-0" High.—When setting marble wainscot 5'-0" to 7'-0" high, a marble setter and helper should set 90 to 110 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1	$.....	$.....	$7.00	$ 7.00
Marble setter	8	.....	.....	6.50	52.00
Helper	8	.....	.....	5.00	40.00
Labor or helper	8	.....	.....	5.00	40.00
Cost 100 sq. ft.	25		$.....		$139.00*
Cost per sq. ft.			.....		1.39

The cost of setting circular wainscot or die will run about double the cost of straight work on account of the extra cutting and fitting.

Wainscot over 7'-0" high will require working from a scaffold which decreases the production considerably. In such cases the labor cost of that portion of wainscot over 7'-0" high should be increased 50 to 100 percent and the cost of erecting and removing steel tubular scaffold should be added.

Setting Marble Wainscot Cap.—When setting marble wainscot cap, a marble setter and helper should set 60 to 75 lin. ft per 8-hr. day, at the following labor cost per 100 lin. ft.:

*Add for overhead and profit.

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	12.0	.....	.....	6.50	78.00
Helper	12.0	.....	.....	5.00	60.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 lin. ft.	33.5		$.....		$188.50*
Cost per lin. ft.					1.89

Setting Marble Stair Treads.—The cost of setting marble stair treads will vary with the thickness and length of the treads because the shorter each piece of marble, the higher the cost per lin. ft.

If the treads are 3′-0″ to 3′-6″ long and 1¼″ thick, a marble setter and helper should set 20 to 22 treads containing 60 to 77 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	11.0	.....	.....	6.50	71.50
Helper	11.0	.....	.....	5.00	55.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 lin. ft.	31.5		$.....		$177.00*
Cost per lin. ft.					1.77

If the treads vary from 4′-0″ to 6′-0″ long, a marble setter and helper should set 80 to 90 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.1	$.....	$.....	$7.00	$ 7.70
Marble setter	9.5	.....	.....	6.50	61.75
Helper	9.5	.....	.....	5.00	47.50
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 lin. ft.	28.1		$.....		$156.95
Cost per lin. ft.			.....		1.57

Setting Marble Stair Risers.—The cost of setting marble stair risers will vary with the length of the pieces of marble, width of stairs, etc.

Where the stairs are 3′-0″ to 3′-6″ wide, a marble setter and helper should set 60 to 75 lin. ft. of risers per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	11.0	.....	.....	6.50	71.50
Helper	11.0	.....	.....	5.00	55.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 lin. ft.	31.5		$.....		$177.00*
Cost per lin. ft.			.....		1.77

*Add for overhead and profit.

If the marble stairs are over 4′-0″ wide, a marble setter and helper should set 80 to 90 lin. ft. of risers per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.1	$.....	$.....	$7.00	$ 7.70
Marble setter	9.5	.....	.....	6.50	61.75
Helper	9.5	.....	.....	5.00	47.50
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 lin. ft.	28.1		$.....		$156.95*
Cost per lin. ft.					1.57

Setting Marble Stair Wainscot on the Rake.—Where marble wainscoting is set on the rake of the stairs, the labor cost will run considerably higher than straight work on account of the additional cutting and fitting necessary.

If the wainscoting is 3′-0″ to 3′-6″ high, a marble setter and helper should set 10 to 15 lin. ft. containing 35 to 45 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	2	$.....	$.....	$7.00	$ 14.00
Marble setter	20	.....	.....	6.50	130.00
Helper	20	.....	.....	5.00	100.00
Labor or helper	8	.....	.....	5.00	40.00
Cost 100 sq. ft.	50		$.....		$284.00*
Cost per sq. ft.					2.84

Where the wainscot is 5′-0″ to 7′-0″ high and follows the rake of the stairs, a marble setter and helper should set 50 to 65 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	14.0	.....	.....	6.50	91.00
Helper	14.0	.....	.....	5.00	70.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 sq. ft.	37.5		$.....		$211.50*
Cost per sq. ft.					2.12

Setting Marble Toilet Stalls and Partitions.—The cost of handling and setting marble toilet stalls, backs, partitions, stiles, etc., will vary greatly with the individual job. On work of this kind the marble partition slabs are seldom less than 5′-0″ in height and width and each slab contains 25 to 30 sq. ft. of marble. The backs are usually the same height as the partitions but not so wide and each back contains 16 to 20 sq. ft. of marble. The stall fronts or stiles are usually 6″ to 8″ wide and 6′-0″ to 7′-0″ high and extend to the floor to support the dividing partitions where metal standards are not used.

*Add for overhead and profit.

As an average on toilet stall work, a good marble setter should complete a stall in 3 to 3½ hours, after the marble backs are in place. Since the average partition contains about 25 sq. ft. and each stile and cap about 7 sq. ft., a setter and helper should set 75 to 80 sq. ft. of marble per 8-hr. day, at the following labor cost for 1 complete stall exclusive of back:

	Hours	Rate	Total	Rate	Total
Foreman	0.4	$.....	$.....	$7.00	$ 2.80
Marble setter	3.3	.....	.....	6.50	21.50
Helper	3.3	.....	.....	5.00	16.50
Labor or helper	2.6	.....	.....	5.00	13.00
Setting cost 1 stall	9.6		$.....		$53.80*

Toilet partition work is estimated by the sq. ft. by most marble contractors.

Setting Marble Toilet Backs.—The marble backs for toilet stalls are usually 6′-0″ to 7′-0″ high. A marble setter and helper should set 75 to 85 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.2	$.....	$.....	$7.00	$ 8.40
Marble setter	10.0	.....	.....	6.50	65.00
Helper	10.0	.....	.....	5.00	50.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 sq. ft.	29.2		$.....		$163.40*
Cost per sq. ft.			.....		1.63

Setting Marble Stall Partitions.—After the toilet backs have been set, a marble setter and helper should set one dividing partition containing 20 to 25 sq. ft. in about 2 hrs. which is at the rate of 80 to 100 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1	$.....	$.....	$7.00	$ 7.00
Marble setter	9	.....	.....	6.50	58.50
Helper	9	.....	.....	5.00	45.00
Labor or helper	8	.....	.....	5.00	40.00
Cost 100 sq. ft.	27		$.....		$150.50*
Cost per sq. ft.			.....		1.50

Setting Marble Toilet Door Stiles.—When setting door stiles for marble toilet partitions, it is customary to set them on the floor or rest them on plated metal standards. Each stile is 6′-0″ to 7′-0″ high, depending upon the height of the partition and whether it rests on the floor or on a metal standard.

A marble setter and helper should set about 8 stiles, contain-

*Add for overhead and profit.

ing 40 to 50 lin. ft. of marble per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	2	$.....	$.....	$7.00	$ 14.00
Marble setter	18	.....	.....	6.50	117.00
Helper	18	.....	.....	5.00	90.00
Labor or helper	8	.....	.....	5.00	40.00
Cost 100 lin. ft.	46		$.....		$261.00*
Cost per lin. ft.					2.61

Setting Marble Cap on Stall Partitions.—When setting marble cap on marble stall partitions, a marble setter and helper should set 60 to 75 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	12.0	.....	.....	6.50	78.00
Helper	12.0	.....	.....	5.00	60.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 lin. ft.	33.5		$.....		$188.50*
Cost per lin. ft.					1.89

Setting Marble Door and Window Trim.—A marble setter and helper should set 45 to 55 lin. ft. of marble door and window trim or casings per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	2	$.....	$.....	$7.00	$ 14.00
Marble setter	16	.....	.....	6.50	104.00
Helper	16	.....	.....	5.00	80.00
Labor or helper	8	.....	.....	5.00	40.00
Cost 100 lin. ft.	42		$.....		$238.00*
Cost per lin. ft.			.....		2.38

Setting Marble Countertops.—When setting marble countertops, a marble setter and helper should set 75 to 85 sq. ft. per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.2	$.....	$.....	$7.00	$ 8.40
Marble setter	10.0	.....	.....	6.50	65.00
Helper	10.0	.....	.....	5.00	50.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 sq. ft.	29.2		$.....		$163.40*
Cost per sq. ft.					1.63

Setting Marble Thresholds.—When setting marble thresholds 3'-0" to 3'-6" long, a marble setter and helper should set 12 to

*Add for overhead and profit.

14 thresholds per 8-hr. day, at the following labor cost each:

	Hours	Rate	Total	Rate	Total
Foreman	0.08	$.....	$.....	$7.00	$ 5.60
Marble setter	.60	.....	.....	6.50	3.90
Helper	.60	.....	.....	5.00	3.00
Labor or helper	.20	.....	.....	5.00	1.00
Cost per threshold	1.48		$.....		$13.50*

Setting Marble Plinths.—When setting marble plinths at door openings, a marble setter and helper should set 20 to 25 plinths per 8-hr. day, at the following labor cost per 100 plinths:

	Hours	Rate	Total	Rate	Total
Foreman	4.5	$.....	$.....	$7.00	$ 31.50
Marble setter	36.0	.....	.....	6.50	234.00
Helper	36.0	.....	.....	5.00	180.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 plinths	84.5		$.....		$485.50*
Cost per plinth			.....		4.86

Setting Marble Stair Railing and Balusters.—On jobs having marble balusters up to 6" in diameter and 2'-6" long, a marble setter and helper should set about 20 balusters per 8-hr. day, at the following labor cost per 100 balusters:

	Hours	Rate	Total	Rate	Total
Foreman	5	$.....	$.....	$7.00	$ 35.00
Marble setter	40	.....	.....	6.50	260.00
Helper	40	.....	.....	5.00	200.00
Labor or helper	16	.....	.....	5.00	80.00
Cost 100 balusters	101		$.....		$575.00*
Cost per baluster			.....		$5.75

Setting Marble Ashlar.—Where marble ashlar is used for the interior walls of buildings, it is customary to use $\frac{7}{8}$" or $1\frac{1}{4}$" marble and the method of handling and setting is similar to that used for setting exterior work, as it is often necessary to use a light breast derrick to set the marble.

On work of this kind, a marble setter and helper should handle and set 60 to 80 sq. ft. of ashlar per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.5	$.....	$.....	$7.00	$ 10.50
Marble setter	12.0	.....	.....	6.50	78.00
Helper	12.0	.....	.....	5.00	60.00
Labor or helper	24.0	.....	.....	5.00	120.00
Cost 100 sq. ft.	49.5		$.....		$268.50*
Cost per sq. ft.			.....		$2.69

*Add for overhead and profit.

Setting Marble Moldings, Handrail, Etc.—On jobs having light marble moldings, stair handrail, well hole rail, etc., where the marble is about 6" square and furnished in reasonably long pieces, a marble setter and helper should set 75 to 85 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1.2	$.....	$.....	$7.00	$ 8.40
Marble setter	10.0	.....	.....	6.50	65.00
Helper	10.0	.....	.....	5.00	50.00
Labor or helper	8.0	.....	.....	5.00	40.00
Cost 100 lin. ft.	28.2		$.....		$163.40*
Cost per lin. ft.			.....		1.63

Setting Marble Column Bases.—When setting marble column bases 2'-6" to 3'-0" square and 0'-9" to 1'-3" high, a marble setter and helper should handle and set about one base an hr. at the following labor cost per base:

	Hours	Rate	Total	Rate	Total
Foreman	0.1	$.....	$.....	$7.00	$ .70
Marble setter	1.0	.....	.....	6.50	6.50
Helper	1.0	.....	.....	5.00	5.00
Labor or helper	2.0	.....	.....	5.00	10.00
Cost per base	4.1		$.....		$22.20*

Laying Marble Floor Tile.—There are three labor operations to be considered when estimating the labor cost of setting marble floor tile, viz., the cement bed under the marble floor, labor handling and setting floor tile and the cost of rubbing or smoothing the floors after they have been laid.

As a general rule, the cement bed under the marble floor is 2½" to 3" thick, composed of cement and sand mixed rather dry. It requires about 1½ bbls. of portland cement and one cu. yd. of sand to each 100 sq. ft. of floor.

Material and labor per 100 sq. ft. of floor fill should cost as follows:

	Hours	Rate	Total	Rate	Total
6 sacks portland cement		$.....	$.....	$1.80	$10.80
1 cu. yd. sand		.....	.....	4.00	4.00
Foreman	0.2	.....	.....	7.00	1.40
Marble setter	1.5	.....	.....	6.50	9.75
Helper	3.0	.....	.....	5.00	15.00
Cost 100 sq. ft.	4.7		$.....		$40.95*
Cost per sq. ft.			.....		.41

If the marble floor tile vary from 6"x6" to 12"x12" in size, a marble setter and helper should handle and lay 90 to 110 sq.

*Add for overhead and profit.

ft. of floor per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Foreman	1	$.....	$.....	$7.00	$ 7.00
Marble setter	8	.....	.....	6.50	52.00
Helper	8	.....	.....	5.00	40.00
Labor or helper	8	.....	.....	5.00	40.00
Cost 100 sq. ft.	25		$.....		$139.00*
Cost per sq. ft.			.....		1.39

When laying marble floors it is customary to place the cement bed just ahead of the tile, and the entire work is performed by the setter and helper laying the floor. If the subfloor is sound and even, much marble in residential and light commercial work is only ⅜" thick and set in mastic. Setting costs would average about 15¢ per sq. ft. less, unles the area was small and irregular, or the floor set with an intricate pattern.

Smoothing Marble Floors.—After the marble floors have been laid, it is necessary to rub them with carborundum stone to remove the uneven spots at the joints. It is customary to use a rubbing machine powered by gasoline or electricity, which is operated by one man and runs back and forth over the floors and grinds them to an even surface.

The quantity of floor that can be surfaced per day will vary with the kind of marble used, as it is possible to surface considerably more soft marble than hard marble.

When rubbing and surfacing soft marble, a machine should surface 125 to 150 sq. ft. per 8-hr. day, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Machine expense	6.0	$.....	$.....	$1.25	$ 7.50
Machine operator	6.0	.....	.....	5.50	33.00
Foreman	0.7	.....	.....	7.00	4.90
Cost 100 sq. ft.	6.7		$.....		$45.40*
Cost per sq. ft.			.....		.45

When rubbing and surfacing hard marble, a rubbing machine should surface 100 to 125 sq. ft. of floor per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Machine expense	7.0	$.....	$.....	$1.25	$ 8.75
Machine operator	7.0	.....	.....	5.50	37.50
Foreman	0.8	.....	.....	7.00	5.60
Cost 100 sq. ft.	7.8		$.....		$51.85*
Cost per sq. ft.			.....		.52

Setting Marble Floor Border.—Where the marble floor has

*Add for overhead and profit.

a different colored marble border, the labor setting the border will cost about the same as the balance of the floor.

Setting Structural Slate.—The labor cost of setting structural slate work, such as base, treads and risers, toilet stalls and partitions, etc., will run about the same as for the same class of marble work and should be estimated accordingly.

If, however, field cutting should be required, as is often the case with window stools and door thresholds, the labor costs should be increased 20 to 25 percent as slate is more difficult to work than marble.

Estimating Quantities of Interior Marble

When estimating quantities of interior marble, any fraction of an inch will be treated as a whole inch when figuring.

No piece of marble will be considered as being less than 6" wide and 1'-0" long.

Thickness.—Thicknesses given are approximate but not exact. For slabs gauged to a given thickness, an extra charge of 10 percent to the list price will be made.

Extra Lengths.—On slabs 10'-0" to 12'-0" long, add 10 percent to list price; on slabs over 12'-0" long, add 20 percent.

Extra Widths.—On slabs over 5'-6" wide, add 10 percent to list price.

Polished Both Sides.—Prices given are based on marble having one side polished unless otherwise noted. If both sides are to be polished, add 85 cents per sq. ft. for marbles in Group "A" and "B" and $1.00 per sq. ft. for marbles in Group "C" and "D."

Hone Finish.—Hone finish takes the same price as polished work.

Sand Finish.—If marble is finished with sand finish on one side only, deduct 15 cents per sq. ft. If sand finish on both sides, add 15 cents per sq. ft.

Polished Edges.—For each polished edge on ⅞" and 1¼" thickness, add 50 cts. per lin. ft. of edge; on 1½" and 2" thickness, add 60 cts. per lin. ft.

Beveled or Rounded Edges.—For each beveled or rounded edge on ⅞" and 1¼" thickness, add 50 cts. per lin. ft.; on 1½" and 2" thickness, add 60 cts. per lin. ft.

O. G. Molding.—For single member O. G. Molding $2.30 per lin. ft. of edge on ⅞" thick; $2.70 per lin. ft. on 1¼", and $3.25 per lin. ft. on 1½".

For each additional member, add $1.50 per lin. ft. of edge on ⅞" and 1¼", and $1.80 on 1½".

Countersinking.—For countersinking ¼" deep or less, $1.50 per sq. ft. of surface. For each additional ¼" deeper, or fraction thereof, add extra $1.20 per sq. ft. of surface.

Grooving.—For grooving ¼" deep or less $1.80 per lin. ft. for each groove. For each additional ¼" deeper, or fraction thereof, add extra $1.20 per lin. ft. of each groove.

Rabbeting.—For rabbeting ¼" deep or less, $1.40 per lin. ft. for each rabbet. For each additional ¼" deeper, or fraction thereof, add extra $1.00 cents per lin. ft. of each rabbet.

Special Cutting, Polishing, Drilling, Etc.—All special work other than listed above will be charged for extra.

How to Figure Marble.—Find the cost of one piece of ⅞" thick Alabama Clouded "A," polished one side with square cut edges, finished to size 6'-4"x1'-5".

Multiply

	6'-4"
	1'-5"
Feet (1) x feet (6) = feet	6'-0"
Feet (1) x inches (4) = inches	0'-4"
Inches (5) x feet (6) = inches	2'-6"
Inches (5) x inches (4) = $\frac{1}{12}$ inches	0'-2"
	9'-0"

Figured as 9'-0" @ $2.75, $24.75, cost of piece.

Another method is to use decimals, multiplying 6'-4" or 6.33x1'-5" or 1.417, equals 8.969 or 9 sq. ft.

Shipping Weights of Marble.—The approximate shipping weights of marble, boxed for shipment, are as follows per superficial foot: ⅞" thick 15 lbs.; 1¼" thick 20 lbs.; 1½" thick 24 lbs.; 2" thick 32 lbs.; per cu. ft. 192 lbs.

Approximate Prices per Superficial Foot of ⅞" Marble, Polished One Side

Kind of Marble	
Alabama Clouded "A" or Cream "A"	$4.00
Brocadillo	6.50
Carthage Gray	3.15
French Gray	3.75
Georgia Creole, Cherokee or Mezzotint	3.75
Gravina	4.25
Kasota Pink	3.50
Kasota Yellow	4.00
Light Cloud Vermont	4.00
Napoleon Gray	4.00
Radio Black	4.25
Tennessee Marbles	$4.00
Verde Antique*	6.50
Westfield Green*	6.00
York Fossil	4.00
Foreign Marbles	
Alps Green	7.10
Belgian Black	5.75
Black and Gold	7.75
Botticino	5.00
Bois Jordan	5.75
Breche Oriental	6.50
Grande Antique, French	8.50
Grand Antique, Italian	8.00

*Subject to charge for waxing

Kind of Marble	
Foreign Marbles	
Italian White	$5.50
Italian English Vein	6.00
Onyx Pedrara	9.50
Red Levanto	8.00
Rosato	$5.50
Sienna Gray	7.70
Sienna Yellow	8.00

The above prices are for marble in less than carload lots, uncrated, f.o.b mill. Crating 30 to 40 cts. per sq. ft. for marble up to 2" thick.

Polishing 2nd face, add 70 cts. per sq. ft. for marbles in Group "A" and "B" and 85 cts. per sq. ft. for marbles in Group "C" and "D."

Approximate Lineal Foot Prices of ⅞" Polished Marble Base 6" High

Kind of Marble		Kind of Marble	
Alabama Clouded "A" or Cream "A"	$2.00	York Fossil	$2.00
Brocadillo	3.25	Foreign Marbles	
Carthage Gray	1.60	Alps Green*	3.55
French Gray	1.85	Belgian Black*	2.85
Georgia Creole, Cherokee or Mezzotint	1.85	Black and Gold*	3.85
Gravina	2.15	Botticino*	2.50
Kasota Pink	1.75	Bois Jordan*	2.85
Kasota Yellow	2.00	Breche Oriental	3.25
Light Cloud Vermont	2.00	Grand Antique, French	4.25
Napoleon Gray	2.00	Grand Antique, Italian	4.00
Radio Black	2.15	Italian White	2.75
Tennessee Marbles, such as Pink Tennessee, Gray, etc.	2.00	Italian English Vein	3.00
Verde Antique*	3.25	Onyx Pedrara	4.75
Westfield Green*	3.00	Red Levanto*	4.00
		Rosato*	2.75
		Sienna Gray*	3.85
		Sienna Yellow*	4.00

Base less than 6" in height takes the same price as 6" base.
Base over 6" to 12", double price of 6" base.
No piece of base will be figured as being less than 1'-0" long.
For polished top edge on base, add 45 cts. per lin. ft.
Mitered ends, 7 cents per inch of height.

Approximate Prices on Sand Finish Marble Floor Tile and Border ⅞" Thick

Tile sizes 6"x6" to 1'-0"x2'-0"	Prices per Superficial Foot		
Alabama Clouded "A"	$3.70	Tennessee Pink	$3.70
Carthage Gray	3.00	Tennessee Gray	3.70

*Subject to charge for waxing.

Tile sizes 6"x6" to 1'-0"x2'-0"

Prices per Superficial Foot

Georgia Creole	$3.70	Tennessee Dark	$3.70
Georgia Cherokee	3.70	Verde Antique	6.25
Italian White	4.60	Tavernelle*	5.00
Italian English Vein	5.00	Travertine*	3.70

If wanted with hone finish, add 17 cents per sq. ft.
If wanted with polished finish, add 80 cents per sq. ft.

Approximate Prices on ⅜" Thinset Marble Tiles

	Polished	Honed
Cremo	$1.90	$1.85
Negro-Marquina	2.35	2.30
Rose Aurora	1.75	1.70
Statuary Vein	1.45	1.40
Travertine Filled	1.35	1.30
Travertine Unfilled	1.30	1.25
White, Italian	1.35	1.30

?"x12" tiles, ⅜" thick, 10 tiles per box.

Approximate Lin. Ft. Prices on Marble Wainscot Cap, 1¼" Thick, 4" High

Polished one side and one edge.

Alabama Clouded "A" or Cream "A"	$3.25	Alps Green*	$5.60
Crocadillo	5.20	Belgian Black*	4.70
Carthage Gray	2.80	Black and Gold*	6.00
French Gray	3.00	Botticino*	4.25
Georgia Creole, Cherokee or Mezzotint	3.25	Bois Jordan	4.70
Gravina	3.50	Breche Oriental*	4.75
Sasota Pink	3.00	Grand Antique, French*	6.20
Sasota Yellow	4.25	Grand Antique, Italian*	5.75
Light Cloud Vermont	4.25	Italian White	4.00
Napoleon Gray	4.25	Italian English Vein	4.25
Radio Black	4.25	Onyx Pedrara*	7.35
Tennessee, Pink or Gray	4.25	Red Levanto*	5.10
Verde Antique*	5.20	Rosato*	4.25
Westfield Greens*	4.35	Sienna Gray*	6.15
		Sienna Yellow*	6.00
		Tavernelle*	4.25

Approximate Prices of Marble Stair Treads and Platforms

Furnished with plain nosing, sand rubbed finish. Prices per superficial foot.

*Subject to charge for waxing.

Kind of Marble	Thickness in Inches 1¼"	1½"	2
Alabama Clouded "A"	$5.00	$6.00	$ 7.
Vermont	5.00	6.00	7.
Carthage Gray	4.05	4.95	6.
French Gray	4.70	5.60	7.
Georgia Creole or Cherokee	4.70	5.60	7.
Italian White	6.75	7.75	10.
Italian English Vein	7.50	9.00	11.
Kasota Pink	5.00	6.00	7.
Napoleon Gray	5.00	6.00	7.
Radio Black	5.25	6.30	7.
Tavernelle	6.75	7.75	10.
Tennessee Pink or Gray	5.00	6.00	7.
Travertine, Roman	5.25	6.30	7.
Verde Antique	8.00	9.60	12.

Approximate Prices of Marble Stiles and Rails

1¼" thick, polished 2 sides and edges, prices per lineal foot.

Kind of Marble	Width in Inches 6"	9"	12
Alabama Clouded "A" or Cream "A"	$4.75	$6.00	$ 7.
Brocadillo	6.70	8.90	11.
Carthage Gray	4.30	5.20	6.
French Gray	4.50	5.50	6.
Gravina	5.00	5.70	7.
Georgia Creole, Cherokee or Mezzotint	4.75	5.90	7.
Kasota Pink	4.50	5.50	6.
Kasota Yellow	5.75	5.90	7.
Light Cloud Vermont	5.75	5.90	7.
Napoleon Gray	5.75	5.90	7.
Radio Black	5.75	6.00	7.
Tennessee Pink or Gray	5.75	6.00	7.
Verde Antique*	6.70	8.75	11.
Westfield Green*	5.85	7.80	9.

Foreign Marbles	Width in Inches 6"	9"	12"
Alps Green*	$7.15	$ 9.70	$12.
Belgian Black*	6.30	8.05	10.
Black and Gold*	7.60	10.30	13.
Botticino*	5.60	7.45	9.
Bois Jordan*	6.30	8.05	10.
Breche Oriental*	6.40	8.10	10.
Grand Antique, French	7.90	10.75	13.

*Subject to charge for waxing.

Foreign Marbles	Width in Inches 6″	9″	12″
Grand Antique, Italian	$7.45	$ 9.90	$11.40
Italian White	5.40	5.75	7.00
Italian English Vein	5.60	7.50	9.20
Onyx Pedrara	7.70	12.50	14.70

Approximate Prices of Marble Stiles and Rails

1¼″ thick, polished 2 sides and edges, prices per lineal foot.

Foreign Marbles	Width in Inches 6″	9″	12″
Red Levanto*	$7.60	$10.50	$13.20
Rosato*	5.60	7.45	9.20
Sienna Yellow*	7.60	10.30	13.20
Sienna Gray*	7.80	10.50	13.60
Tavernelle*	5.60	7.45	9.20
Travertine, Roman*	4.75	5.90	7.15

*Subject to charge for waxing.

Lineal Foot Prices of Sand Finished Marble Thresholds

Thresholds 5″ or 6″ wide, beveled 2 edges.

Kind of Marble	Thickness in Inches ⅞″	1¼″
Alabama	$3.00	$3.60
Carthage Gray	3.00	3.60
French Gray	3.00	3.60
Georgia Creole or Cherokee	3.00	3.60
Italian White	3.00	3.60
Italian English Vein	3.00	3.60
Napoleon Gray	3.00	3.60
Radio Black	3.00	3.60
Tavernelle	3.80	5.00
Tennessee Pink or Gray	3.00	3.60
Travertine	3.00	3.60
Verde Antique	4.00	5.40
Vermont	3.00	3.60

Prefabricated marble toilet and shower compartments are being used more and more throughout the country. Compartments are complete with all hardware, metal or (optional) wood doors, and Ozark grey veined marble, polished and drilled for installation. Price per compartment is $125.00 f.o.b. Carthage, Missouri.

EXTERIOR MARBLE

When marble is used for exterior facing the contractor usually obtains this material direct from the quarry and this type of

marble work is handled in the same manner as cut stone or granite work.

The quarry prepares shop and setting drawings and produces the marble in the specified shapes and thicknesses and ships the finished material, usually crated, to the job. The contractor sets the material with stone masons, using stone derricks and other similar equipment as required.

Labor Setting Exterior Marble.—Marble weighs 180 to 200 lbs per cu. ft. or approximately the same as building granite and 15 to 20 percent more than cut stone and, like building granite, requires very careful handling in setting.

On an average, the labor costs for setting exterior marble should be figured 20 to 25 percent higher than those given on previous pages for setting cut stone.

Mortar Required for Setting Exterior Marble.—Use the same quantities of mortar for setting exterior marble as given on previous pages for "Cut Stone."

STRUCTURAL SLATE

Slate is a natural mica granular crystalline stone. Its main sources are Vermont, Pennsylvania and Virginia. Vermont produces colored slates, including greens; purples; mottled green, purple and red; as well as the standard dark grays.

Slate is usually graded into clear stock and ribbon stock. Ribbon stock has bands of a darker color running through it and is cheaper than clear stock, which has no ribbons but will have some spots and veining in it.

Finishes available are as follows:

Natural Cleft—Natural split or cleaved face, moderately rough with some textural variations.

Sand Rubbed Finish—Wet sand on a rubbing bed is used to eliminate any natural cleft, and leave slate in an even plane.

Honed Finish—This is a semi-polished surface.

Slate is used for spandrels, sills, stools, treads and risers, toilet stalls, floors and walks, fireplace facings and hearths.

Spandrels are generally clear slate with either cleft, rubbed or honed finish. Thickness is generally 1", 1¼" or 1½". Sizes are somewhat limited, with a length of no more than 6 ft. and width of 2'-6" to 4' being standard recommendations, although larger sizes may be available for certain conditions. Many spandrels today are set in metal grid frames. Otherwise, they must be anchored with bronze or stainless steel anchors in each corner.

Sills and stools may be either ribbon or clear stock. Exterior

sills are generally furnished with a sand rubbed finish in lengths up to 4′ and 1″ to 2″ in thickness. Sills may have drip grooves cut in at additional cost.

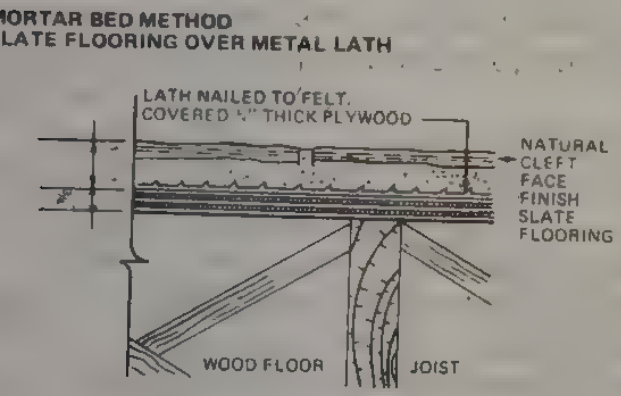
Interior stools and fireplace surrounds are usually 1″ thick with honed finish, a maximum length of 4′ being most economical.

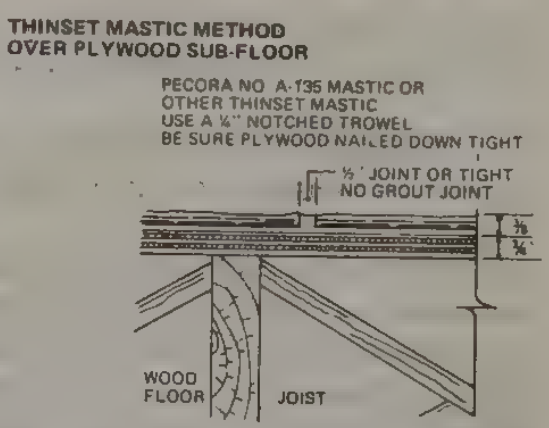
Treads and risers on the exterior are generally natural cleft finish. Interior work is usually sand rubbed rather than honed as it is both cheaper and gives a good non-slip surface, although the front edges may be honed. Thickness is generally 1″ or 1¼″ for stairs, 1½″ to 2″ for landings.

The cost of slate is determined by the grade, the size involved and the finish.

Ribbon grade, often used on stairs, will run around $2.25 per sq. ft. in 1″ thickness and $3.50 for 2″ thickness, sand finished. Honed finishes will add $0.30 per sq. ft. to the cost.

Clear grade, 1″ thick and sand finished, will run $3.50 per sq. ft. in sizes to 3 sq. ft., $4.25 to $4.50 in sizes 3 sq. ft. to 6 sq. ft., and $5.00 to $6.50 in sizes over 6 sq. ft. Lineal foot costs for sills and stools will vary with both length and width. Up to 6″ wide stock will run around $2.25 per lineal foot for 1″ thickness; $3.50 for 2″ thickness. 10″ wide stock will cost $3.25 per lineal foot for 1″ thickness to $5.50 per lineal foot for 2″ thickness.





Slate for flooring is available for either mortar bed or thin set application. This set is ¼″ thick and available in 3″ multiples 3″x6″ to 12″x12″. It weighs 3¾ lbs. per sq. ft. It is set in ⅛″ mastic applied with a notched trowel over concrete or plywood. It can have grouted joints or be ordered for butt joints. Cost will run $120.00 per sq. ft. for material and $1.40 for labor.

Slate for heavier duty floors and for outside applications is generally ½″, ¾″ or 1″ thick, weighing 7½ lbs., 11¼ lbs. and 15 lbs. respectively. It is set in 1″ mortar beds on concrete slabs or plywood. Plywood should be covered with felt and metal lath, then nailed on. Minimum thickness is 1½″. If plywood is set over joists

without a subfloor, it should be at least ¾" thick. Sizes are 6"x6" to 24"x18", in multiples of 3". Cost runs from $3.00 per sq. ft. for ½" to $4.00 for 1".

CHAPTER XXIII

TILE FLOORS AND WALLS, TERRAZZO AND COMPOSITION FLOORS, AND ACOUSTIC TILE

CERAMIC WALL AND FLOOR TILE

Ceramic tile provides a durable, colorful surface that is virtually maintenance-free. Its applications include interior and exterior finishes as well as countertops, for functional and decorative purposes in all types of structures. Special uses include acid resistant and electrically conductive installations.

Ceramic tile is available in many sizes, shapes and finishes. Terms of reference for the most commonly used ceramic tile are:

Glazed Ceramic Wall Tile—Ceramic tile that has an impervious facial finish fused onto the body of the tile. The glazed surface comes in a wide variety of colors.

Ceramic Mosaic Tile—Ceramic tile, either glazed or unglazed, having a facial area of less than six square inches and which is usually mounted on sheets or mesh approximately 2 feet by 1 foot to facilitate setting.

Quarry Tile—A rugged ceramic tile used primarily as a finish flooring (interior and exterior) where a long wearing, easily cleanable surface is desired.

Recent developments in the ceramic tile industry make it necessary to stress the importance of relating tile costs to each individual job specification. Glazed ceramic wall tile, for example, can be backmounted or unmounted, and can be installed using conventional portland cement mortar, various types of adhesives or the more recently developed 'dry-set' portland cement mortar. All of these variations can affect costs, both material and labor, and, consequently, the estimator should review his job requirements carefully prior to making the estimate.

The above notwithstanding, the estimator's job has been simplified in recent years. Virtually the entire ceramic tile industry has adopted a 'simplified practice', prepared under the auspices of the Tile Council of America, which has reduced the number of sizes and shapes and which has established generally recognized standards for the Industry.

Estimating Quantities—Ceramic tile is estimated by the square

foot, with trim pieces such as base, cap, etc. being estimated by the lineal foot. The estimator should deduct door and window openings, but the trim pieces necessary to finish the openings must be added. The quantities should be related to the type and size of ceramic tile, since these items will affect the cost of the ceramic tile when priced.

Estimate Composition—The finished ceramic tile estimate will include the following items:

1. Cost of ceramic tile delivered to the job site.
2. Cost of accessory materials such as wire mesh, sand and cement for floor fill under ceramic tile.
3. Cost of mixing and placing floor fill.
4. Direct labor cost of laying and cleaning the ceramic tile.
5. The ceramic tile contractor's overhead and profit.

Variable Factors Influencing Costs—As in the other construction trades, estimating the labor costs of setting ceramic tile requires an intimate knowledge of the labor market in which the work is to be performed. Wage rates vary throughout the country and it is important the estimator determine the rate in his locality. Employers' contributions to fringe benefits, as well as the various taxes and insurance requirements, are becoming increasingly important when estimating labor costs. For example, in New York City the employers' contributions to such as pension, vacation and welfare funds alone amount to 10% of the tile setter base hourly rate. The estimator can determine the rates applicable by contacting the union local in his area.

Ceramic tile is unique in that it is often necessary to install it in very small quantities (for example, in 1 or 2 bathrooms in a house) and, therefore, the costs can vary greatly. It is felt, however, that such small installations are the exception, rather than the norm, and, therefore, the costs given on the following pages are based on the assumption that the areas involved are large enough to permit the tile contractor to operate efficiently. At the conclusion of the costs developed, a table of factors to use with smaller jobs is given.

The costs developed on the following pages are based on $4\frac{1}{4}$"x$4\frac{1}{4}$" glazed wall tile, 1"x1" ceramic mosaic tile and 6"x6"x$\frac{1}{2}$" quarry tile, since these are the sizes most commonly employed. If other sizes are specified, substitute the material price only. For all practical purposes, the labor cost remains constant regardless of size. The developed costs do not include areas where an unusually large amount of trim is required. Therefore, the estimator should make an allowance for extra trim pieces in such special cases.

When ceramic tile is to be applied to a plaster base the question arises as to who will do the plastering work, the tile contractor or the plasterer. The estimator should check the building trade jurisdictional agreements in his area. If no information is available, assume that the tile contractor will plaster bathrooms, vestibules and small halls in private residences and that all other plasterwork will be by the plastering contractor. For information on the cost of plastering, see Chapter XVIII.

Setting Methods—Recent years have seen the development of many methods of adhering ceramic tile to a subsurface. There are, however, three methods which are most commonly used and accepted. These are:

Conventional Portland Cement Mortar Method. This method is to bond each ceramic tile with a layer of pure portland cement paste to a portland cement setting bed. This is done while the setting bed is still plastic. Wall tile must be soaked in water so that the water needed for curing is not absorbed from the paste. While being the traditionally accepted method, it is also more costly than the other methods.

Dry-Set Portland Cement Mortar Method. This method utilizes

Dry-set Mortar and Back Mounted Tile Sheets.

a dry curing portland cement mortar (accomplished through the use of water retaining additives) and has made ceramic tile installation cheaper and simpler. "Dry-set" is ideally suitable for use with concrete masonry, brick, poured concrete and portland cement plaster. It should not be used over wood or gypsum plaster. Labor costs are appreciably reduced when this method is used.

Water-Resistant Organic Adhesive. Organic adhesives can be used over smooth base materials, such as wallboards, plywood and metal. It should not, however, be used in wet areas over surfaces that are subject to moisture penetration. Labor productivity is comparable to that of 'dry-set' mortar.

Labor Productivity

(sq. ft. per team day; team is 1 tile setter & 1 helper)

	Description	Face-mounted	Back-mounted	Unmounted
Conventional Mortar	Glazed wall tile	....	75-90 SF	55-65 SF
	Ceramic mosaic tile—walls	45-50 SF	55-65 SF	....
	floors	100-125 SF	100-125 SF	....
	Quarry tile floors	....	....	100-125 SF
'Dry-Set' Mortar	Glazed wall tile	....	125-150 SF	100-125 SF
	Ceramic mosaic tile—walls	100-125 SF	120-140 SF	....
	floors	125-150 SF	125-150 SF	....
	Quarry tile floors	....	....	125-150 SF
Organic Adhesive	Glazed wall tile	....	150-175 SF	120-140 SF
	Ceramic mosaic tile—walls	120-140 SF	125-150 SF	....
	floors	150-175 SF	175-200 SF	....
	Quarry tile floors	....	....	....

Cove or Base	65-75 lin. ft.
Cap	80-90 lin. ft.

APPROXIMATE PRICES ON CERAMIC TILE MATERIALS

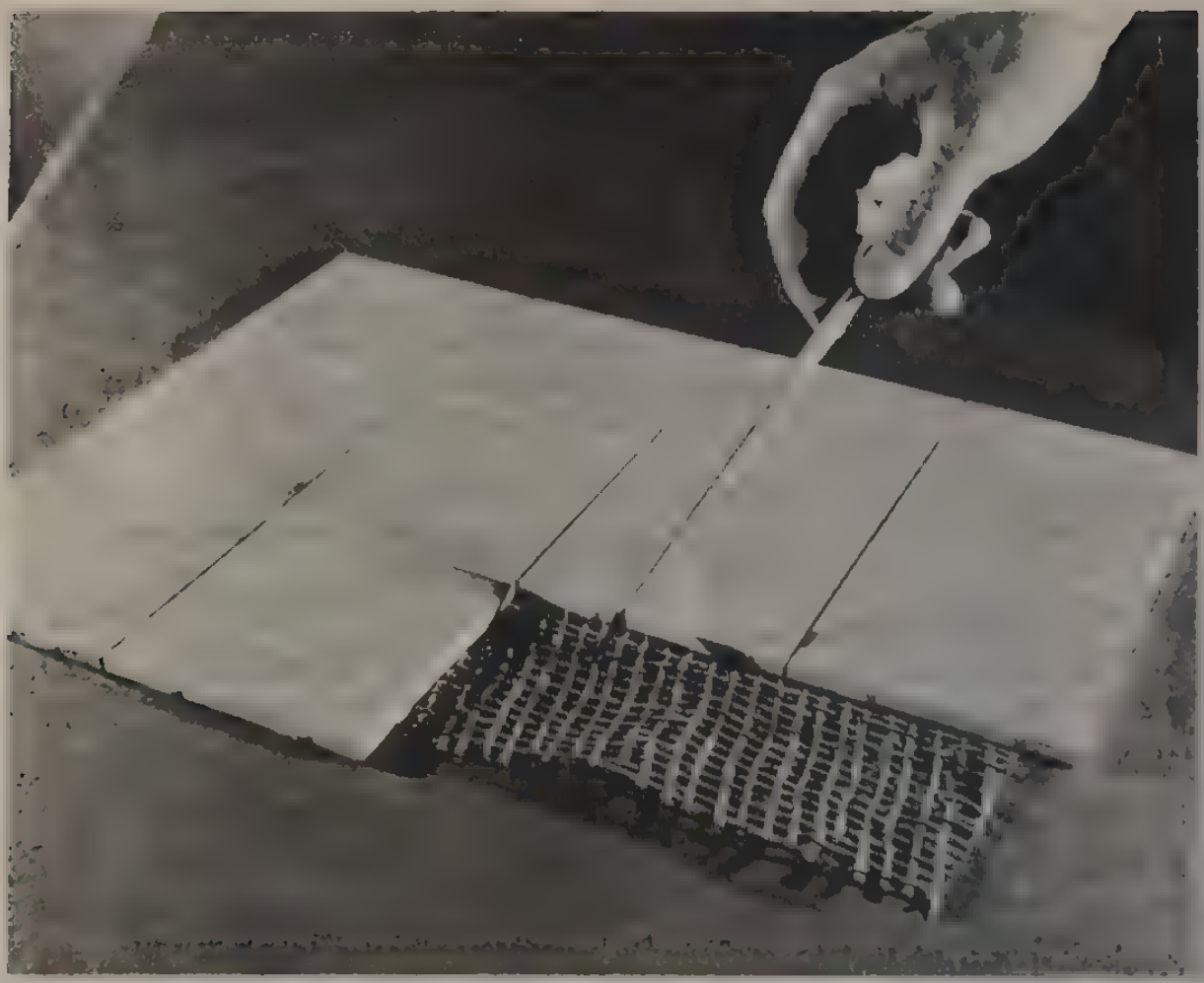
Ceramic Wall Tile

Description	Size	Price per sq. ft.
Flat tile, all colors, including white	4¼"x4¼"	$0.65
	6 "x6 "	.67
	6 "x4¼"	.61
	6 "x9 "	.95
	8½"x4¼"	.66

Trimmers Serial No.[2 3]			Price per piece [1]
	for use with 4¼"x4¼" tile		
A1663	Cove	6 "x3¾"	$0.25
A3401	Cove	4¼"x4¼"	.20
S4269	Bullnose	2 "x6 "	.16
A4200	Bullnose	2 "x6 "	.18
S4449	Bullnose	4¼"x4¼"	.20
A4402	Bullnose	4¼"x4¼"	.20
S7449	Double bullnose	4¼"x4¼"	.30
A7440	Double bullnose	4¼"x4¼"	.32
AK106	Universal concave angle		.10
	for use with 6"x6" tile		
A3601	Cove	6 "x6 "	$0.30
S4669	Bullnose	6 "x6 "	.30
A3602	Bullnose	6 "x6 "	.30
A7610	Double bullnose	6 "x6 "	.50
	miscellaneous trim shapes		
A106	Bead	6 "x ¾"	$0.10
A1662	Bullnose	6 "x3¾"	.25
A3410	Base	6 "x4 "	.32
A3610	Base	6 "x6 "	.34
A4225	Sink Trim	6 "x2 "	.27
A7590	Window Sill	9 "x5⅛"	.80

NOTES:

1) Prices are for stretchers; for angles, multiply prices by two.
2) 'S' indicates surface type, 'A' indicates conventional type.
3) Add 20% to price of any trim piece requiring special cutting or glazing on edge.



Glazed Wall Tile of the 4¼ by 4¼ Inch Size Mounted on Mesh Backing

Ceramic Mosaic Tile

Description (price per sq. ft.)
Unglazed, Modular, Solid Color

	White & Grays	Other Colors
1 "x1 "	$0.65	from $0.70 to $0.80
2 "x1 "	.70	.70 to .80
2 "x2 "	.72	.75 to .85
¾"x ¾"	.65	.70 to .80
1 9/16"x ¾"	.65	.70 to .80
1 9/16"x1 9/16"	.68	.70 to .80
1" Hexagon	.50 (White)	.70 (black)

Trim Shapes (price per lineal foot)

1"x1" Bullnose	$0.35	S862
1"x1" Bullnose	.45	C812
2"x1" Bullnose	.45	C832

¾" Series trim pieces same price as 1" Series
Various manufacturers furnish, as standard items, patterns made

from combinations of modular tile sizes and colors. Prices vary depending on number of different sizes used, number of colors used and depth of colors used. Patterns such as these are too numerous to itemize, but the general range is from $0.60 to $0.75 per sq. ft. There are exceptions to this range however, and when a specific pattern price is needed, the estimator should check with the specified supplier.

Abrasive Ceramic Mosaic Tile.....from $0.67 to $0.77 per sq. ft.
Conductive Floor Tile..... $0.98 per sq. ft.
Granitized Ceramic Mosaic Tile....from $0.51 to $0.60 per sq. ft.
Abrasive Granitized Ceramic Mosaic Tile .....from $0.63 to $0.72 per sq. ft.
Glazed Satin Finish Ceramic Mosaic Tile ..... $0.67 per sq. ft.
Glazed Textured Finish Ceramic Mosaic Tile ..... $0.78 per sq. ft.
Special Decorative Glazed Ceramic Mosaic Tile for Accent Effects...from $2.50 to $10.00 per sq. ft.

Note: For all of the above, add $0.08 per sq. ft. for back-mounted material.

Venetian glass mosaics mounted on sheets 12¼"x12¼" square run $1.50 a sq. ft. For ¾"x¾" $1.70 for 1"x1" and $1.75 for 1½"x1½". Metallic finishes run considerably more. Beads and coves for glass mosaics will run 50 cts. a lin. ft.

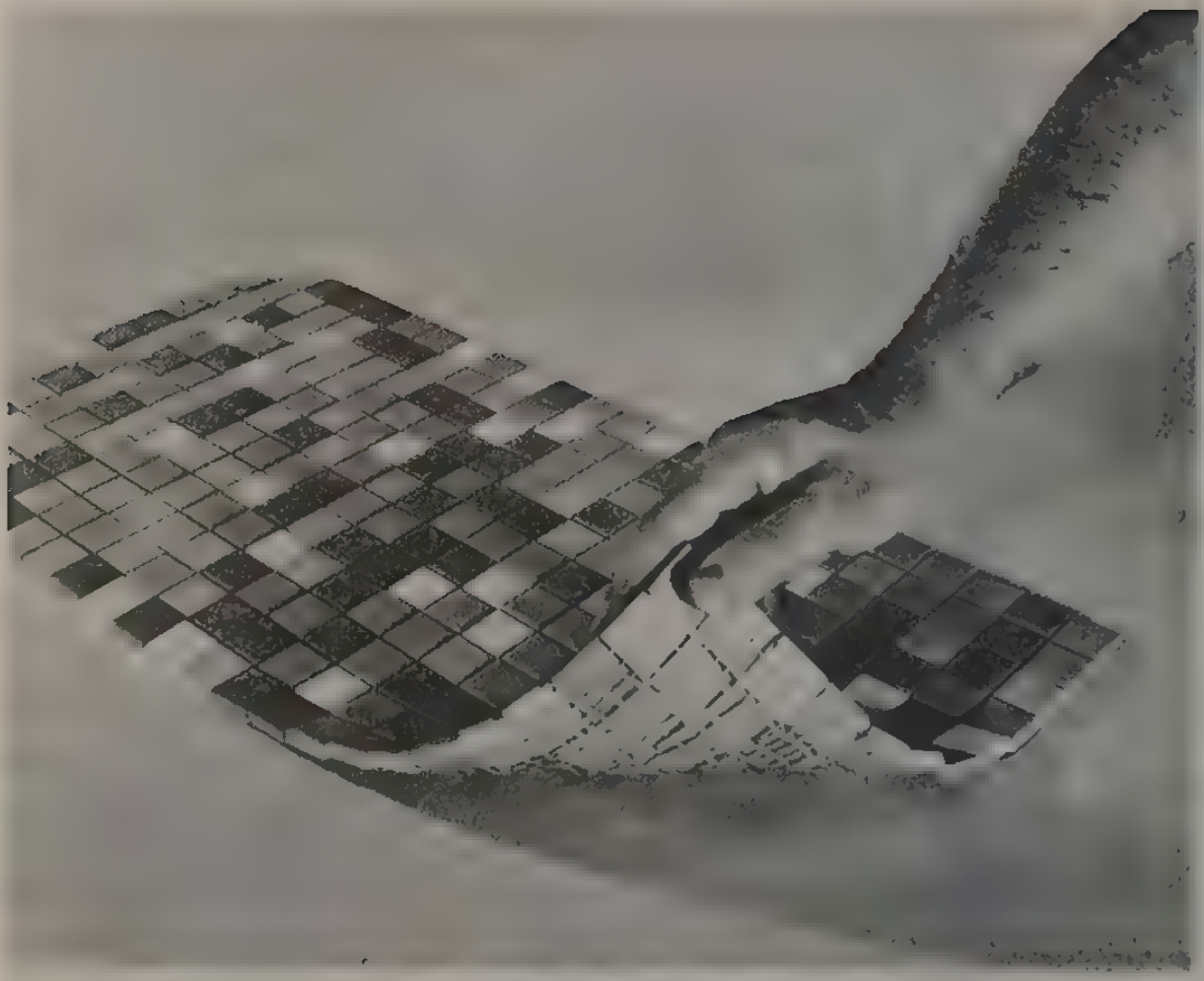
Sculptured tiles which can be used for wall surfacing, murals, screens and sculpture are available in a wide range of ceramic designs and treatments. Design-Technics of New York have tiles in sizes 4¼"x8½"x¼" at approximately $4 to $5 a sq. ft., 12"x12"x⅜" at $5 to $6.25 a sq. ft. and 12"x12"x1¾" at $6.50 to $7.75 a sq. ft.

Quarry Tile

Description	Size	Price per sq. ft.
Deep red, plain surface	6"x6 "x½"	$0.55
	6"x2¾"x½"	.55
	6"x6 "x¾"	.60
	9"x9 "x¾"	.67
	8"x2¼"x¾"	.65
Deep red, abrasive	6"x6 "x½"	.65
	6"x6 "x¾"	.70

Note: Other colors, with the exception of green, are virtually the same price as the red shown above. Green in the 6"x6"x½" size costs $0.90 per sq. ft.

Extras, when specified, are:
Tile ground square after burning.....$0.04 per sq. ft.
Wax coating ..... .04 per sq. ft.



Ceramic Mosaic Tile of 1 by 1 Inch Tile, Back Mesh Mounted.

Floor brick, deep red, plain

tray packed	8"x4"x1⅜"	$ 85.00 per M pieces
in sealed cartons		$130.00 per M pieces

Floor brick, deep red, abrasive

tray packed	8"x4"x1⅜"	$ 95.00 per M pieces
in sealed cartons		$140.00 per M pieces

Trim pieces, deep red, plain surface

Serial Number	Description	Size	Price per piece
Q1665	Bullnose	6"x6"x½"	$0.20
Q1465	Bullnose	4"x6"x½"	.20
Q1990	Bullnose	9"x9"x¾"	.32
Q1660	Bullnose	6"x6"x¾"	.20
Q1690	Bullnose	6"x9"x¾"	.25
Q3565	Cove base	5"x6"x½"	.20
Q3266	Cove base	2"x6"x½"	.20
Q6666	Stair tread	6"x6"x¾"	.20
QC6666	Stair tread angle	6"x6"x¾"	.40

Ceramic Tile Bathroom Accessories

Numerous ceramic tile bathroom accessories are available in a variety of sizes and qualities. They may be recessed or surface mounted and they come in the full range of tile colors. Some of the more commonly used items are as follows:

Description	Price per piece White	Other Colors
Recessed soap holder	$0.80	$1.50
Recessed glass holder	.80	1.50
Roll paper holder	.90	1.80
Robe hook	.70	1.25
Double robe hook	.80	1.50
Toothbrush holder	.80	1.50
Tile bar brackets (pair)	1.25	2.50
Tile rod—18"	.85	1.30
Tile rod—24"	1.05	1.55
Tile rod—30"	1.20	1.80

Decorative Ceramic Wall Tiles

Glazed ceramic wall tile containing designs as an integral part of each piece of tile is also available. Normally supplied in 4¼"x4¼" and 6"x6" sizes, the price of this material will vary with the design selected and number of colors in the design. If the design is known, the estimator should obtain a firm price from a supplier. The general range is as follows:

One color	4¼"x4¼"	$1.50 per sq. ft.
	6"x6"	1.25 per sq. ft.
Two colors	4¼"x4¼"	1.75 per sq. ft.
	6"x6"	1.50 per sq. ft.
Three colors	4¼"x4¼"	2.00 per sq. ft.
	6"x6"	1.65 per sq. ft.

Ceramic Tile Adhesives and Accessory Materials

Item	Coverage	Price
Organic adhesive	40-50 sf/gal	$3.00/gal.
Dry-set mortar mix	35 lbs./100 sf	.20/lb.
Primer (for use in damp areas)	125 sf/gal.	3.25/gal.
Plastic underlayment	100 sf/unit*	6.00/unit*
Wet tile grout	15-20 sf/lb.**	.10/lb.
Dry tile grout	12-15/sf/lb.**	.15/lb.

*unit consists of 1 gallon liquid & 34 lbs. aggregate.
**when used with 4¼"x4¼" tile.

Cost of 100 sq. ft. of 4¼"x4¼" Glazed Ceramic Wall Tile using conventional mortar method of installation (unmounted tile).

	Hours	Rate	Total	Rate	Total
2 sacks portland cement.		$.....	$.....	$2.00	$ 4.00
4 cu. ft. sand		.....	.....	.20	.80
100 sq. ft. glazed wall tile		.....	.....	.65	65.00
7 lbs. wet tile grout mix..		.....	.....	.10	.70
Tile setter	13.5	.....	.....	6.50	87.75
Helper	13.5	.....	.....	5.00	67.50
Cost per 100 sq. ft.	27.0		$.....		$225.75
Cost per sq. ft.			.....		2.26

Cost of 100 sq. ft. of 4¼"x4¼" Glazed Ceramic Wall Tile using water resistant organic adhesive (unmounted tile).

	Hours	Rate	Total	Rate	Total
2.5 gallons adhesive		$.....	$.....	$3.00	$ 7.50
100 sq. ft. glazed wall tile		.....	.....	.65	65.00
9 lbs. dry tile grout mix..		.....	.....	.15	1.35
Tile setter	6.5	.....	.....	6.50	42.25
Helper	6.5	.....	.....	5.00	32.50
Cost per 100 sq. ft.	13.0		$.....		$148.60
Cost per sq. ft.			.....		1.49

Cost of 100 sq. ft. of 4¼"x4¼" Glazed Ceramic Wall Tile using 'dry-set' portland cement mortar (unmounted tile).

	Hours	Rate	Total	Rate	Total
35 lbs. 'dry-set' mortar mix		$.....	$.....	$0.20	$ 7.00
100 sq. ft. glazed wall tile		.....	.....	.65	65.00
9 lbs. dry tile grout mix..		.....	.....	.15	1.35
Tile setter	8.0	.....	.....	6.50	52.00
Helper	8.0	.....	.....	5.00	40.00
Cost per 100 sq. ft.	16.0		$.....		$165.35
Cost per sq. ft.			.....		1.65

Note: Add for plastering when specified under "Tilework."

Cost of 100 sq. ft. of 4¼"x4¼" Glazed Ceramic Wall Tile using conventional mortar method of installation (back-mounted tile).

	Hours	Rate	Total	Rate	Total
2 sacks portland cement.		$.....	$.....	$2.00	$ 4.00
4 cu. ft. sand		.....	.....	.20	.80
100 sq. ft. glazed wall tile		.....	.....	.73	73.00
7 lbs. wet tile grout mix..		.....	.....	.10	.70
Tile setter	10.0	.....	.....	6.50	65.00
Helper	10.0	.....	.....	5.00	50.00
Cost per 100 sq. ft.	20.0		$.....		$193.50
Cost per sq. ft.			.....		1.94

Cost of 100 sq. ft. of 4¼"x4¼" Glazed Ceramic Wall Tile using water resistant organic adhesive (back-mounted tile).

	Hours	Rate	Total	Rate	Total
2.5 gallons adhesive		$.....	$.....	$3.00	$ 7.50
100 sq. ft. glazed wall tile		.....	.....	.73	73.00
9 lb. dry tile grout mix..		.....	.....	.15	1.35
Tile setter	5.5	.....	.....	6.50	35.75
Helper	5.5	.....	.....	5.00	27.50
Cost per 100 sq. ft.	11.0		$.....		$145.10
Cost per sq. ft.			.....		1.45

Cost of 100 sq. ft. of 4¼"x4¼" Glazed Ceramic Wall Tile using 'dry-set' portland cement mortar (back-mounted tile).

	Hours	Rate	Total	Rate	Total
35 lbs. 'dry-set' mortar mix		$.....	$.....	$0.20	$ 7.00
100 sq. ft. glazed wall tile		.....	.....	.73	73.00
9 lbs. dry tile grout mix..		.....	.....	.15	1.35
Tile setter	6.5	.....	.....	6.50	42.25
Helper	6.5	.....	.....	5.00	32.50
Cost per 100 sq. ft.	13.0		$.....		$156.10
Cost per sq. ft.					1.56

Note: Add for plastering when specified under "Tilework."

Cost of 100 sq. ft. 1"x1" Ceramic Mosaic Tile floors using conventional mortar method of installation (face-mounted tile).

	Hours	Rate	Total	Rate	Total
2 sacks portland cement.		$.....	$.....	$2.00	$ 4.00
4 cu. ft. sand		.....	.....	.20	.80
100 sq. ft. ceramic mosaic tile		.....	.....	.65	65.00
17 lbs. wet tile grout mix		.....	.....	.10	1.70
Tile setter	8.0	.....	.....	6.50	52.00
Helper	8.0	.....	.....	5.00	40.00
Cost per 100 sq. ft.	16.0		$.....		$163.50
Cost per sq. ft.			.....		1.64

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile floors using water resistant organic adhesive (face-mounted tile).

	Hours	Rate	Total	Rate	Total
2.5 gallons adhesive		$.....	$.....	$3.00	$ 7.50
100 sq. ft. ceramic mosaic tile		.....	.....	.65	65.00
23 lbs. dry tile grout mix		.....	.....	.15	3.45
Tile setter	5.5	.....	.....	6.50	35.75
Helper	5.5	.....	.....	5.00	27.50
Cost per 100 sq. ft.	11.0		$.....		$139.20
Cost per sq. ft.			.....		1.39

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile floors using 'dry-set' portland cement mortar (face-mounted tile).

	Hours	Rate	Total	Rate	Total
35 lbs. 'dry-set' mortar mix		$.....	$.....	$0.20	$ 7.00
1 cu. ft. of sand		.....	.....	.20	.20
100 sq. ft. ceramic mosaic tile		.....	.....	.65	65.00
23 lbs. dry tile grout mix		.....	.....	.15	3.45
Tile setter	6.5	.....	.....	6.50	42.25
Helper	6.5	.....	.....	5.00	32.50
Cost per 100 sq. ft.	13.0		$.....		$150.40
Cost per sq. ft.					1.50

Note: Add for cement floor fill or plastic underlayment when required.

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile floors using conventional mortar method of installation (back-mounted tile).

	Hours	Rate	Total	Rate	Total
2 sacks portland cement.		$.....	$.....	$2.00	$ 4.00
4 cu. ft. sand		.....	.....	.20	.80
100 sq. ft. ceramic mosaic tile		.....	.....	.73	73.00
17 lbs. wet tile grout mix		.....	.....	.10	1.70
Tile setter	8.0	.....	.....	6.50	52.00
Helper	8.0	.....	.....	5.00	40.00
Cost per 100 sq. ft.....	16.0		$.....		171.50
Cost per sq. ft.			.....		1.72

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile floors using water resistant organic adhesive (back-mounted tile).

	Hours	Rate	Total	Rate	Total
2.5 gallons adhesive		$.....	$.....	$3.00	$ 7.50
100 sq. ft. ceramic mosaic tile	.....	.....	.....	.73	73.00
23 lbs. dry tile grout mix		.....	.....	.15	3.45
Tile setter	5.0	.....	.....	6.50	32.50
Helper	5.0	.....	.....	5.00	25.00
Cost per 100 sq. ft.	10.0		$.....		$141.45
Cost per sq. ft.			.....		1.41

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile floors using 'dry-set' portland cement mortar (back-mounted tile)

	Hours	Rate	Total	Rate	Total
35 lbs. 'dry-set' mortar mix		$.....	$.....	$0.20	$ 7.00
1 cu. ft. sand	.....	.....	.....	.20	.20
100 sq. ft. ceramic mosaic tile	.....	.....	.....	.73	73.00
23 lbs. dry tile grout mix		.....	.....	.15	3.45
Tile setter	6.5	.....	.....	6.50	42.25
Helper	6.5	.....	.....	5.00	32.50
Cost per 100 sq. ft.	13.0		$.....		$158.40
Cost per sq. ft.			.....		1.58

Note: Add for cement floor fill or plastic underlayment when required.

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile on walls using conventional mortar method of installation (face-mounted tile).

	Hours	Rate	Total	Rate	Total
2 sacks portland cement.		$.....	$.....	$2.00	$ 4.00
4 cu. ft. sand	.....	.....	.....	.20	.80
100 sq. ft. ceramic mosaic tile	.....	.....	.....	.65	65.00
17 lbs. wet tile grout mix		.....	.....	.10	1.70
Tile setter	16.0	.....	.....	6.50	104.00
Helper	16.0	.....	.....	5.00	80.00
Cost per 100 sq. ft.	32.0		$.....		$255.50
Cost per sq. ft.			.....		2.56

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile on walls using water resistant organic adhesive (face-mounted tile).

	Hours	Rate	Total	Rate	Total
2.5 gallons adhesive		$.....	$.....	$3.00	$ 7.50
100 sq. ft. ceramic mosaic tile		.....	.....	.65	65.00
23 lbs. dry tile grout mix		.....	.....	.15	3.45
Tile setter	6.5	.....	.....	6.50	42.25
Helper	6.5	.....	.....	5.00	32.50
Cost per 100 sq. ft.	13.0		$.....		$150.70
Cost per sq. ft.			.....		1.51

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile on walls using 'dry-set' portland cement mortar (face-mounted tile).

	Hours	Rate	Total	Rate	Total
35 lbs. 'dry-set' mortar mix		$.....	$.....	$0.20	$ 7.00
1 cu. ft. of sand		.....	.....	.20	.20
100 sq. ft. ceramic mosaic tile		.....	.....	.65	65.00
23 lbs. dry tile grout mix		.....	.....	.15	3.45
Tile setter	8.0	.....	.....	6.50	52.00
Helper	8.0	.....	.....	5.00	40.00
Cost per 100 sq. ft.	16.0		$.....		$167.65
Cost per sq. ft.			.....		1.68

Note: Add for plastering when specified under "Tilework."

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile on walls using conventional mortar method of installation (back-mounted tile).

	Hours	Rate	Total	Rate	Total
2 sacks portland cement.		$.....	$.....	$2.00	$ 4.00
4 cu. ft. sand		.....	.....	.20	.80
100 sq. ft. ceramic mosaic tile		.....	.....	.73	73.00
17 lbs. wet tile grout mix		.....	.....	.10	1.70
Tile setter	13.5	.....	.....	6.50	87.75
Helper	13.5	.....	.....	5.00	67.50
Cost per 100 sq. ft.	27.0		$.....		$234.75
Cost per sq. ft.			.....		2.35

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile on walls using water resistant organic adhesive (back-mounted tile).

	Hours	Rate	Total	Rate	Total
2.5 gallons adhesive		$.....	$.....	$3.00	$ 7.50
100 sq. ft. ceramic mosaic tile		.....	.....	.73	73.00
23 lbs. dry tile grout mix		.....	.....	.15	3.45
Tile setter	6.5	.....	.....	6.50	42.25
Helper	6.5	.....	.....	5.00	32.50
Cost per 100 sq. ft.	13.0		$.....		$158.70
Cost per sq. ft.			.....		1.59

Cost of 100 sq. ft. of 1"x1" Ceramic Mosaic Tile on walls using 'dry-set' portland cement mortar (back-mounted tile).

	Hours	Rate	Total	Rate	Total
35 lbs. 'dry-set' mortar mix		$.....	$.....	$0.20	$ 7.00
1 cu. ft. sand		.....	.....	.20	.20
100 sq. ft. ceramic mosaic tile		.....	.....	.73	73.00
23 lbs. dry tile grout mix		.....	.....	.15	3.45
Tile setter	6.5	.....	.....	6.50	42.25
Helper	6.5	.....	.....	5.00	32.50
Cost per 100 sq. ft.	13.0		$.....		$158.40
Cost per sq. ft.			.....		1.58

Note: Add for plastering when specified under "Tilework."

Cost of 100 sq. ft. of 6"x6"x½" Quarry Tile floors using conventional mortar method of installation

	Hrs.	Rate	Total	Rate	Total
2 sacks portland cement.		$.....	$.....	$2.00	$ 4.00
6 cu. ft. sand		.....	.....	.20	1.20
100 sq. ft. quarry tile		.....	.....	.55	55.00
35 lbs. portland cement grout		.....	.....	.02	.70
Tile setter	8.0	.....	.....	6.50	52.00
Helper	8.0	.....	.....	5.00	40.00
Cost per 100 sq. ft.	16.0		$.....		$152.90
Cost per sq. ft.			.....		1.53

Cost of 100 sq. ft. of 6″x6″x½″ Quarry Tile floors using 'dry-set' portland cement mortar

	Hrs.	Rate	Total	Rate	Total
35 lbs. 'dry-set' mortar mix		$.....	$.....	$0.20	$ 7.00
2 cu. ft. of sand		.....	.....	.20	.40
100 sq. ft. quarry tile		.....	.....	.55	55.00
35 lbs. portland cement grout		.....	.....	.02	.70
Tile setter	6.5	.....	.....	6.50	42.25
Helper	6.5	.....	.....	5.00	32.50
Cost per 100 sq. ft.	13.0		$....		$137.85
Cost per sq. ft.			.....		1.38

Cost of 100 lin. ft. of cove or base (Ceramic or Quarry Tile)

	Hrs.	Rate	Total	Rate	Total
100 lin. ft. cove #A1663		$.....	$.....	$0.50	$ 50.00
Tile setter	11.5	.....	.....	6.50	74.75
Helper	11.5	.....	.....	5.00	57.50
Adhesive or mortar—allow		.....	.....	....	5.00
Cost per 100 lin. ft.	23.0		$.....		$187.25
Cost per lin. ft.					1.87

Cost of 100 lin. ft. of wainscot cap (Glazed Ceramic Wall Tile)

	Hrs.	Rate	Total	Rate	Total
100 lin. ft. cap #A4210		$.....	$.....	$0.36	$ 36.00
Tile setter	9.0	.....	.....	6.50	58.50
Helper	9.0	.....	.....	5.00	45.00
Adhesive or mortar—allow		.....	.....	.....	3.00
Cost per 100 lin. ft.	18.0		$.....		$142.50
Cost per lin. ft.			.....		1.43

Note: Add for cement floor fill, plastic underlayment, or plastering when required.

Placing Cement Floor Fill—Cement floor fill under ceramic tile floors is usually placed by tile setters and helpers, one tile setter and one or two helpers working together. The fill is placed one or two days in advance of the tile if the overall thickness from rough floor to finished tile surface is over 3″. For 3″ thickness and under, fill and setting bed may be placed in one operation. When such tile floors are to be placed over wood subfloors it is necessary to first place a layer of waterproof building paper and a layer of wire mesh reinforcing before placing the fill.

A tile setter and two helpers should place 450 to 500 sq. ft. of fill per 8-hour day in areas large enough to permit efficient operations, at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
6 bags portland cement		$.....	$.....	$1.80	$10.80
1 cu. yd. sand		.....	.....	4.00	4.00
Tile setter	1.5	.....	.....	6.50	9.75
Helper	3.0	.....	.....	5.00	15.00
Cost per 100 sq. ft.	4.5		$.....		$39.55
Cost per sq. ft.					.40

Labor Factors For Small Quantities

		Labor multiplier
Ceramic Mosaic Tile	Small rooms	1.75
	Countertops	3.00
Glazed Ceramic Wall Tile	Small rooms	1.50
	Mantel fronts	2.00
	Mantel front w/returns	1.90
Cove or Base	Small rooms	1.25
Cap	Small rooms	1.10

To estimate the cost of the smaller job, multiply the labor costs given in the applicable unit price development by the appropriate labor multiplier. Material cost does not change.

Plastic Wall Tile

Plastic wall tile made of Styron, Polystyrene and other similar plastics, is usually furnished in 4¼"x4¼" and 9"x9" size, and in many colors, plain, gronite tone, and marbleized.

Plastic tile is used as wainscoting in bathrooms, kitchens, laundries and any space where other kinds of wall tile may be used.

A smooth base must be provided, such as plaster, gypsum wallboard, or other smooth, hard surfaced materials. Never apply plastic tile over porous insulating board.

Plastic tile may be cut with a cutter similar to that used for asbestos shingles.

It requires about 2½ gals. adhesive for 100 sq. ft. of tile. Price $3.50 per gal.

Plastic tile cost from 35 to 55 cts. per sq. ft. depending upon manufacturer, quality and color.

After the base has been prepared ready to receive tile, an experienced man should apply 80 to 100 sq. ft. of tile per 8-hr. day.

Cost of 100 Sq. Ft. Plastic Wall Tile

	Hours	Rate	Total	Rate	Total
105 sq. ft. tile		$.....	$.....	$0.45	$47.25
2½ gals. adhesive			.....	3.50	8.75
Mechanic	9			6.50	58.50
Cost 100 sq. ft.	9		$.....		$114.50
Cost per sq. ft.			.....		1.15

Metal Wall Tile

Wall tile of aluminum, having a baked enamel finish in various colors, or tile of copper or stainless steel are used for the same purposes as plastic wall tile.

They require the same type of base; are applied with adhesive and a man will apply about the same number of square feet per day as given above for plastic tile.

Metal tile mastic weighs about 16 lbs. per gal. and it requires ½-lb. per sq. ft. or one gal. is sufficient for 32 sq. ft. of tile. Price about $3.50 per gal. Aluminum metal tile cost about 35 to 45 cts. per sq. ft. Copper or stainless steel tile cost about $1.25 per sq. ft.

TERRAZZO WAINSCOT, FLOORS, BASE AND BORDER

The cost of terrazzo work varies with the size of the job, size of rooms or spaces where the floors are to be installed, floor designs, strips of brass or other non-rusting material, and method of laying the floors.

Two methods are used in laying terrazzo floors over concrete construction. One is to bond it to the concrete and the other to separate it from the structural slab.

When the first method is used, the concrete fill is provided for by another contractor and should be left 2" below the finished floor. This concrete can be made of cement, sand and hard coal cinders in proportion of 1:1:6. Soft coal cinders must not be used. Slag, broken stone or gravel are also good aggregates for concrete fill under terrazzo floors. Before the terrazzo contractor installs his underbed, he must see that this concrete fill is thoroughly cleaned of plaster droppings, wood chips and other debris, and wetted to insure cohesion.

The second method is used in buildings where cracking is anticipated either from settlement, expansion and contraction or vibration. In this case the terrazzo contractor begins his work from the structural floor slab up. This method requires a thickness of at least 3". The concrete slab is covered with a thin bed of dry sand over which a sheet of tar paper is laid. Over the paper the underbed is installed as in the first method

except that coarser aggregate can be used in the underbed, such as cinders or fine gravel where its thickness exceeds 2½". When this method is used, the cracks originating in the structural slab are not likely to appear on the surface but terminate at the sand bed.

When terrazzo is laid over wood floors a thickness of not less than 2" is required. The floor should first be covered with tarred paper. Over this paper, nail galvanized wire netting No. 14 gauge, 2" mesh. Then lay the concrete underbed as specified under the second method.

The underbed for terrazzo consisting of 1 part portland cement and 4 parts sharp, screened sand shall be spread and brought to a level not less than ½" nor more than ¾" below the finished floor.

Into this underbed, while still in a semi-plastic state, install metal strips or preassembled decorative units, having proper bonding features.

The terrazzo topping shall be not less than ½" nor more than ¾" in thickness and shall be of granulated marble of colors selected. The topping shall be uniform in composition and the marble granule that appears on the surface shall be used for its entire thickness. The granule to be composed of such proportions of Nos. 1-2-3 sizes as required.

Composition for terrazzo mixture shall be in the proportion of 200 lbs. of marble granules to 100 lbs. of gray or white portland cement, mixed dry and water afterward added to make the mix plastic but not too wet. The mix shall then be placed in the spaces formed by the metal dividing strips and rolled into a compact mass by means of heavy stone or metal rollers until all superfluous cement and water is extracted, after which, it must be hand troweled to an even surface, disclosing the lines of the metal strips on a level with the terrazzo filling.

When the floors have set sufficiently hard, they shall be machine rubbed, using coarse carborundum grit stones for the initial rubbing after which a light grouting of pure gray or white portland cement shall be applied to the surface, filling all voids, and allowed to remain until the time of final cleaning.

Floors shall have the grouting coat removed by machine, using a fine carborundum grit, after which it must be thoroughly washed. Do not use acids in cleaning terrazzo floors.

Ramped or other surfaces in terrazzo floors so specified, shall be made anti-slip by the addition of an abrasive aggregate. For heavy duty floors, the proportion shall be 2 parts of abrasive to 3 parts of marble granule and the abrasive shall be mixed in the terrazzo topping for its entire thickness. For light traffic floors, the abrasive shall be sprinkled on the surface only, and show a

proportion of 5 parts marble granule and 1 part abrasive aggregate.

Terrazzo Base.—Terrazzo base is usually coved at the floor and may be any height desired. If the base is to finish flush with the finish plaster, a metal base bead shall be furnished and set by the plasterer. The base shall be divided approximately every 4 lin. ft. using metal base dividers. The walls back of the base shall have a scratch coat of cement and sand mortar brought to a line ⅜" back of the finished face of the base, into which the base dividers shall be set. Base shall be finished with a very fine stone, so as to leave the surface at a hone finish.

Estimating the Cost of Terrazzo Work.—In addition to the direct cost of labor and materials entering into terrazzo work, an allowance should be made to provide for wood grounds, carborundum stone for rubbing, wiring for electric power, depreciation on machines, use of hoist, cleaning up rubbish, freight and trucking on machines and tools. This will vary with size and location of job.

The costs on the following pages are based on an average job containing about 3,000 sq. ft. as the labor on a small job containing 100 to 200 sq. ft. will run twice as much per sq. ft. as on a job containing 5,000 sq. ft.

Miscellaneous Job Costs, Overhead Expense, Profit, Etc.—The amounts included under miscellaneous job expenses to cover such items as wood grounds, carborundum rubbing stone, wiring for electric power, electric power, depreciation on machines, use of hoist, cleaning up rubbish, freight and trucking, etc. are averages. On large jobs these amounts may be reduced somewhat but on small jobs they may be increased. An allowance of 10 to 15 cts. per sq. ft. or per lin. ft. should be figured to take care of the above items.

An average allowance for contractor's overhead expense and profit is about 35 percent. On large jobs this percentage may be reduced to 20 or 25 percent, while on small jobs it may be increased to 40 to 50 percent.

The estimator should use his own judgment when allowing for the above items, based on local conditions at the time of letting the work.

Metal Strips in Terrazzo Floors and Base.—Brass strips or other non-rusting metals are used in practically all terrazzo floors and add to the cost in proportion to the quantity used.

Standard brass strips B & S gauge No. 20 cost 12 to 15 cts. per lin. ft. including waste.

Metal strips B & S gauge No. 14, cost 20 to 25 cts. per lin. ft.

including waste in brass and 10 to 12 cts. per lin. ft. in zinc.

The cost of metal strips per sq. ft. of floor will vary with the size of the squares or design and should be estimated accordingly.

Terrazzo base is jointed every 4'-0" with vertical metal joint dividers. No. 20 gauge brass averages about 10 to 15 cts. per joint. No. 14 gauge metal base dividers average 18 to 25 cts. per joint for brass and 8 to 12 cts. for zinc.

Estimating Quantities of Terrazzo Work.—Terrazzo floors are estimated by the sq. ft. and will vary from 2" to 3" thick, depending upon the subfloor, as described in the previous paragraphs.

Terrazzo floor borders are estimated by the sq. ft. when over 12" wide and by the lin. ft. when less than 12" wide.

Terrazzo base is estimated by the lin. ft. stating height. An allowance of 1'-0" should be made for each corner or miter.

Double cove terrazzo base having 2 finished faces, such as ordinarily used under narrow partitions, shower stalls, etc., are estimated by the lin. ft. and the cost is double that of single cove base.

Labor Placing Terrazzo, Floor and Base.—The labor cost of placing terrazzo work will vary with the size of the rooms, design of the floor, size of the squares or pattern requiring brass strips, etc., as the smaller the squares, the more metal strip required and the higher the cost.

The following are approximate quantities of various classes of terrazzo work a crew of 2 mechanics and 3 helpers should install per 8-hr. day:

Description of Work	No. Sq. Ft. per 8-Hr. Day	Hrs. per 100 Sq. Ft. Mechanic	Helpers
Floor blocked off into 5'-0" squares	400—450	3.75	5.65
Floor blocked off into 4'-0" squares	375—425	4.00	6.00
Floor blocked off into 3'-0" squares	350—400	4.25	6.40
Floor blocked off into 2'-0" squares	325—375	4.60	6.90
Floor blocked off into 1'-0" squares	275—325	5.33	8.00
Floor border 12" to 24" wide	275—325	5.33	8.00
Terrazzo Cove Base	**No. Lin. Ft.**	**Hours per 100 Lin. Ft.**	
Terrazzo cove base, 3" high	60—65	13	13
Terrazzo cove base, 6" high	50—55	16	16

Double cove base, double prices given for single base.

Rubbing and Finishing Terrazzo Work.—Terrazzo floors are rubbed by machine and by hand only in corners where the machine cannot reach.

On jobs consisting of large and small rooms, a man will rub and complete about 100 sq. ft. of terrazzo floor per 8-hr. day.

A man should rub and finish about 80 lin. ft. of terrazzo base per 8-hr. day.

Cost of Concrete Subbase Under Terrazzo Floors.—As described in the previous paragraphs, there are three methods of applying the concrete underbed for terrazzo floors; whether bonded to the structural concrete slab, separate from the structural slab or applied over wood floors.

Inasmuch as terrazzo topping is ¾" thick for all types of floors, cost of finished floor varies with type of underbed.

Cost of 100 Sq. Ft. of Concrete Underbed 1¼" Thick Bonded To Structural Concrete Slab

	Rate	Total	Rate	Total
3 sacks portland cement..	$.....	$.....	$1.80	$5.40
11 cu. ft. sand.....	.....	.....	.16	1.76
Cost 100 sq. ft.....		$.....		$7.16
Cost per sq. ft.....		.....		.07

Labor is included in cost of placing terrazzo floor.

Cost of 100 Sq. Ft. of Concrete Underbed, Consisting of ¼" Dry Sand, 1 Thickness Tarred Felt and 2" of Concrete, Terrazzo Floor Separated From Structural Slab

	Hours	Rate	Total	Rate	Total
2.5 cu. ft. dry sand.....		$.....	$.....	$0.16	$ 0.40
1 sq. roll No. 15 felt.....		.....	.....	.75	.75
Labor placing sand and felt	1	.....	.....	5.00	5.00
4.5 sacks portland cement		.....	.....	1.80	8.10
18 cu. ft. sand.....		.....	.....	.16	2.88
Cost 100 sq. ft.....	1		$.....		$17.13
Cost per sq. ft.....			.....		.17

Cost of 100 Sq. Ft. of Concrete Underbed 2" Thick, Applied Over Wood Floor

	Hours	Rate	Total	Rate	Total
1 sq. roll No. 15 felt.....		$.....	$.....	$0.75	$ 0.75
105 sq. ft. No. 14 ga. galv. wire netting		.....	.....	.03	3.15
Labor, felt and netting...		.....	.....	5.00	5.00
4.5 sacks portland cement		.....	.....	1.80	8.10
18 cu. ft. sand.....		.....	.....	.16	2.88
Cost 100 sq. ft.....	1		$.....		$19.88
Cost per sq. ft.....			.....		.20

Cost of Materials for 100 Sq. Ft. of Terrazzo Floor ¾" Thick Applied Over Concrete Underbed

	Rate	Total	Rate	Total
3 sacks portland cement..	$.....	$.....	$1.80	$ 5.40
600 lbs. marble granules..	.....	.....	.02*	12.00*
0.5 sack port.cement (grout)	.....	.....	1.80	.90
Cost 100 sq. ft.....		$.....		$18.30
Cost per sq. ft.....		.....		.18

Cost of Marble Granules.—Marble granules of domestic marbles average about $2.00 per 100 lbs. and foreign marbles about $3.25 per 100 lbs.

Cost of 100 Sq. Ft. Terrazzo Floors Blocked Into 5'-0" Squares, Including 1¼" Concrete Underbed

Underbed 1¼" Thick	Hours	Rate	Total	Rate	Total
3 sacks portland cement..		$.....	$.....	$1.80	$ 5.40
11 cu. ft. sand		.....	.....	.16	1.76
Terrazzo Floor					
3 sacks portland cement..		.....	.....	1.80	5.40
600 lbs. marble granules..		.....	.....	.02*	12.00*
0.5 sack cement (grout)..		.....	.....	1.80	.90
50 lin. ft. metal strips....		.....	.....	.15**	7.50**
Mechanic	3.75	.....	.....	6.50	24.38
Helper	5.65	.....	.....	5.00	28.25
Labor rub and finish.....	8.00	.....	.....	5.00	40.00
Misc. job expense.....		.....	.....	.12	12.00
Cost 100 sq. ft.....	17.40		$.....		$137.59
Cost per sq. ft.....			.....		1.38

If terrazzo is placed over wood subfloor or separated from concrete floor, add difference in cost of underbed.

Cost of 100 Sq. Ft. Terrazzo Floors Blocked Into 4'-0" Squares, Including 1¼" Concrete Underbed

Underbed 1¼" Thick	Hours	Rate	Total	Rate	Total
3 sacks portland cement..		$.....	$.....	$1.80	$ 5.40
11 cu. ft. sand.....		.....	.....	.16	1.76
Terrazzo Floor					
3 sacks portland cement..		.....	.....	1.80	5.40
600 lbs. marble granules..		.....	.....	.02*	12.00*
0.5 sack cement (grout)..		.....	.....	1.80	.90
60 lin. ft. metal strips....		.....	.....	.15**	9.00**
Carried Forward			$.....		$34.46

*Varies according to kind of granules used. **Varies according to kind and gauge of metal.

Cost of 100 Sq. Ft. Terrazzo Floors Blocked Into 4'-0" Squares, Including 1¼" Concrete Underbed—Continued

	Hours	Rate	Total	Rate	Total
Brought Forward		$.....	$.....	$.....	$34.46
Mechanic	4	.....	.....	6.50	26.00
Helper	6	.....	.....	5.00	30.00
Labor rub and finish	8	.....	.....	5.00	40.00
Misc. job expense		.....	.....	.12	12.00
Cost 100 sq. ft.	18		$.....		$142.46
Cost per sq. ft.					1.42

If terrazzo is placed over wood subfloor or separated from concrete floor, add difference in cost of underbed.

Cost of 100 Sq. Ft. Terrazzo Floors Blocked Into 3'-0" Squares, Including 1¼" Concrete Underbed

Underbed 1¼" Thick	Hours	Rate	Total	Rate	Total
3 sacks portland cement		$.....	$.....	$1.80	$ 5.40
11 cu. ft. sand		.....	.....	.16	1.76
Terrazzo Floor					
3 sacks portland cement		.....	.....	1.80	5.40
600 lbs. marble granules		.....	.....	.02*	12.00*
0.5 sack cement (grout)		.....	.....	1.80	.90
80 lin. ft. metal strips		.....	.....	.15**	12.00**
Mechanic	4.25	.....	.....	6.50	27.63
Helper	6.40	.....	.....	5.00	32.00
Labor rub and finish	8.00	.....	.....	5.00	40.00
Misc. job expense		.....	.....	.12	12.00
Cost 100 sq. ft.	18.65		$.....		$149.09
Cost per sq. ft.					1.49

If terrazzo is placed over wood subfloor or separated from concrete floor, add difference in cost of underbed.

Cost of 100 Sq. Ft. Terrazzo Floors Blocked Into 2'-0" Squares, Including 1¼" Concrete Underbed

Underbed 1¼" Thick	Hours	Rate	Total	Rate	Total
3 sacks portland cement		$.....	$.....	$1.80	$ 5.40
11 cu. ft. sand		.....	.....	.16	1.76
Terrazzo Floor					
3 sacks portland cement		.....	.....	1.80	5.40
600 lbs. marble granules		.....	.....	.02*	12.00*
0.5 sack cement (grout)		.....	.....	1.80	.90
120 lin. ft. metal strips		.....	.....	.15**	18.00**
Mechanic	4.6	.....	.....	6.50	29.90
Carried Forward			$.....		$73.36

*Varies according to kind of granules used. **Varies according to kind and gauge of metal.

Cost of 100 Sq. Ft. Terrazzo Floors blocked Into 2'-0" Squares, Including 1¼" Concrete Underbed—Continued

	Hours	Rate	Total	Rate	Total
Brought Forward		$.....	$.....	$.....	$73.36
Helper	6.9	.....	.....	5.00	34.50
Labor rub and finish	8.0	.....	.....	5.00	40.00
Misc. job expense		.....	.....	.12	12.00
Cost 100 sq. ft.	19.5		$.....		$159.86
Cost per sq. ft.					1.60

If terrazzo is placed over wood subfloor or separated from concrete floor, add difference in cost of underbed.

Cost of 100 Sq. Ft. Terrazzo Floors Blocked Into 1'-0" Squares, Including 1¼" Concrete Underbed

Underbed 1¼" Thick	Hours	Rate	Total	Rate	Total
3 sacks portland cement		$.....	$.....	$1.80	$ 5.40
11 cu. ft. sand		.....	.....	.16	1.76
Terrazzo Floor					
3 sacks portland cement		.....	.....	1.80	5.40
600 lbs. marble granules		.....	.....	.02*	12.00*
0.5 sack cement (grout)		.....	.....	1.80	.90
210 lin. ft. metal strips		.....	.....	.15**	31.50**
Mechanic	5.35	.....	.....	6.50	34.78
Helper	8.00	.....	.....	5.00	40.00
Labor rub and finish	8.00	.....	.....	5.00	40.00
Misc. job expense		.....	.....	.12	12.00
Cost 100 sq. ft.	21.35		$.....		$183.74
Cost per sq. ft.			.....		1.84

If terrazzo is placed over wood subfloor or separated from concrete floor, add difference in cost of underbed.

Cost of 100 Lin. Ft. of 6" Terrazzo Cove Base

Scratch Coat	Hours	Rate	Total	Rate	Total
1.5 sacks portland cement		$.....	$.....	$1.80	$ 2.70
3 cu. ft. sand		.....	.....	.16	.48
Terrazzo Base					
1 sack portland cement		.....	.....	1.80	1.80
200 lbs. marble granules		.....	.....	.02*	4.00*
25 metal dividers		.....	.....	.15**	3.75**
Mechanic	16	.....	.....	6.50	104.00
Helper	16	.....	.....	5.00	80.00
Labor rub and finish	10	.....	.....	5.00	50.00
Carried Forward			$.....		$246.73

*Varies according to kind of granules used. **Varies according to kind and gauge of metal.

Cost of 100 Lin. Ft. of 6" Terrazzo Cove Base—Continued

	Hours	Rate	Total	Rate	Total
Brought Forward		$.....	$.....	$.....	$246.73
Misc. job expense.....		.....	.....	.12	12.00
Cost 100 lin. ft.....	42		$.....		$258.73
Cost per lin. ft.....			.....		2.59

†Add for overhead expense and profit.

Double cove base, double cost of single cove base.

Abrasive Materials for Terrazzo Floors and Stair Treads.—Where an anti-slip surface is required on terrazzo floors, platforms, landings and treads, mix 2 parts abrasive aggregates with 3 parts marble granule. For heavy duty floors the abrasive aggregate shall be mixed in the terrazzo topping for its entire thickness. For light traffic floors, the abrasive shall be sprinkled on the surface only, to show in the proportion of 3 parts marble granule and 1 part abrasive aggregate.

Abrasive aggregates for 100 sq. ft. of heavy duty floors should cost as follows:

	Rate	Total	Rate	Total
240 lbs. abrasive aggregates	$.....	$.....	$0.50	$120.00
360 lbs. marble granules..	.....	.....	.02*	7.20*
Cost 100 sq. ft.....		$.....		$127.20
Cost per sq. ft.		.....		1.27

*Varies according to kind of granules used.

Deduct cost of marble granules included in itemized estimates.

Abrasive aggregates for 100 sq. ft. of light duty floors should cost as follows:

	Rate	Total	Rate	Total
10 lbs. abrasive aggregates	$.....	$.....	$0.50	$5.00
30 lbs. marble granules...	.....	.....	.02*	.60*
Cost 100 sq. ft.....		$.....		$5.60
Cost per sq. ft.....		.....		.06

*Varies according to kind of granules used.

For prices on special terrazzo floors such as venetian, mosaic and conductive, it is advisable to contact a local installation contractor.

There are several products on the market that resemble terrazzo floors and are installed by terrazzo mechanics. These are magnisite, latex, epoxy, and polyester resin type terrazzo floors. These floors can be installed over any sound existing floor in ½" thickness, with the exception of the epoxy and polyester resin types which can be installed as thin as the marble granules will allow. The costs of these floors are similar to that of regular terrazzo.

Resilient Flooring

Resilient flooring includes asphalt tile, linoleum, rubber, cork, vinyl asbestos, pure vinyl tile and vinyl sheet flooring. Each type has its own qualities and should be selected on these considerations rather than cost alone. If material is to be installed on or below grade linoleum, cork tile and certain sheet vinyls are not suitable.

If grease is a problem, rubber, cork and asphalt tile perform poorly, while if resilience and quietness are important, cork and rubber tile are excellent, but sheet vinyl is poor.

A quick guide for approximate installed costs per sq. ft. is as follows:

Type	Thickness	Cost
Asphalt tile	3/32"-1/8"	$0.20-0.35
Vinyl asbestos	1/16"	0.25-0.35
	3/32" & 1/8"	0.30-0.45
Linoleum	.090"	0.30-0.45
	1/8"	0.45-0.65
Vinyl sheet	.065"	0.40-0.60
Cork tile	1/8", 3/16", 5/16"	0.60-0.75
Vinyl tile	.050"	0.70-0.90
Vinyl sheet	.070"	0.70-0.90
Rubber tile	1/8"	0.70-0.95
Vinyl sheet	.090"	0.75-1.25
Vinyl tile	1/8"	1.05-2.20
Cork with vinyl coating	1/8"	1.50-1.85

ASPHALT TILE FLOORS

Asphalt tile is one of several types of resilient flooring that can be used satisfactorily on concrete floors that are in direct contact with the ground, at or below grade. Hence it is suitable for basement rooms, as it is not affected by the moisture and alkali always present in concrete in contact with the ground. Asphalt tile are also used in residences, stores, offices and institutions where a low cost floor is desired.

They are furnished in a variety of colors, and in 1/8" and 3/16" thicknesses. Tile sizes available are 9"x9" in all colors and 18"x24" in "A" and "B" colors.

When applied over approved wood subfloors, the wood floor shall be finished smooth and level and covered with a layer of lining felt bonded to the wood with linoleum paste and then rolled thoroughly with a linoleum roller. The asphalt tile are then laid over the lining felt, using an approved asphalt emulsion for bonding the tile to the felt.

When applied over concrete floors, above, at or below grade,

the concrete floor must be smooth, dry and even. The tile is laid directly on the concrete, using approved asphalt emulsion. At grade or subgrade, if dampness due to humidity is extreme, the concrete shall be given one coat of asphalt cut-back primer after which the tile are laid in asphalt—solvent type or cutback—cement.

How to Estimate Asphalt Tile Floors

To Determine and Price the Quantity of Material Required from an Actual Layout.—This method is the most accurate for computing the cost of material and is the recommended procedure if time will permit.

First, prepare a working drawing according to plans and specifications; then determine the quantity of asphalt tile and border material required. After the gross quantities (actual square feet plus an allowance for waste) have been determined, multiply them by the square-foot price which is dependent on the color and quantity, and on extra charges for special sizes and shapes. The result will be the price of the material.

To Determine and Price the Quantity of Material Required When the Field and Border Are of the Same Color.—Compute the actual square footage of surface to be covered, and add a percentage for waste. The percentage will depend on the size of the area and regularity of outline. A fair percentage of waste to add to the actual area is shown in the accompanying table.

After the gross area has been determined, multiply it by the square-foot price of asphalt tile. The result will be the price of the material.

The square-foot price of the material will depend on the colors and quantity.

Table of Approximate Percentages of Allowable Waste for Various Areas

Up to	50	sq. ft.	14%		
50 to	100	sq. ft.	10%		
100 to	200	sq. ft.	7%	to	9%
200 to	300	sq. ft.	6%	to	7%
500 to	1,000	sq. ft.	4%	to	5%
1,000 to	5,000	sq. ft.	4%		
5,000 to	10,000	sq. ft.	3%	to	4%
10,000 and up			1½%	to	3%

To Determine and Price the Quantity of Material Required When the Field and Border Consist of Different Colors.—This method can be used when time is a factor and the size of the job is of such proportion as to make it impossible to prepare a layout and estimate quantities so as to submit the price within the time limit.

Compute the actual square-foot area, and add a percentage for waste as outlined under the accompanying table. The result will be the gross area.

If a border is used, the gross area will consist of both border and field material. The border material will range from 10% to 20% of the gross area, depending on the regularity of outline.

Example: Assume a room size of 20'-0"x12'-0" with an offset of 6'-0"x9'-0".

Determine the square footage of both border and field material.

20'-0" x 12'-0"	240 sq. ft.
9'-0" x 6'-0"	54 sq. ft.
Total net area	294 sq. ft.
Add 6% waste	18 sq. ft.
Total gross area	312 sq. ft.

In this example the outline is practically regular. Hence:

a. Border material equals approximately 16% of the gross area or—50 sq. ft.

b. Field material equals approximately 84% of the gross area or—262 sq. ft.

c. Total—312 sq. ft.

The result is approximate but is accurate enough for quick estimating.

Quantity of Linoleum Paste Required.—Depending upon the condition of the subfloor, one gallon of linoleum paste for installing lining felt should cover approximately 140 sq. ft. Costs about $1.00 per gal.

Quantity of Primer and Asphalt Cement Required.—When priming concrete floors, one gallon of primer should cover 200 to 300 sq. ft. of surface, depending upon the porosity of the surface. Price $1.30 per gal.

One gallon of asphalt cement should lay 175 to 225 sq. ft. of asphalt tile over concrete subfloors depending upon the condition of the subfloors. Costs about $1.50 per gal.

One gallon of asphalt emulsion for installing asphalt tile over lining felt on wood subfloors and direct to suspended concrete subfloors will cover approximately 140 to 175 sq. ft. Price $1.10 per gal.

Labor Laying Asphalt Tile.—The cost of laying asphalt tile varies with the size and shape of the room or space where the tile are to be laid, size of tile, kind of subfloor, etc., as a tile setter will lay more sq. ft. of tile in a large room than one cut

up with pilasters, offsets, etc., also a man will lay more sq. ft. of large size tile than of the smaller sizes.

When placing lining felt over wood subfloors, an experienced man should spread paste, lay and roll 250 to 300 sq. ft. of felt an hr. depending upon the room sizes.

After the lining felt has been laid (over wood floors), an experienced tile setter should lay the following qantities of tile per 8-hr. day:

Size of Tile	No. Sq. Ft. Laid per 8-Hr. Day	Hours per 100 Sq. Ft.
9"x 9"	400—425	2.0

The above quantities are based on fairly large rooms. If laid in small spaces, increase labor costs accordingly.

Sq. Ft. Prices on Asphalt Floor Tile

The following are average prices on asphalt tile.

Group	⅛"
A colors	$0.12
B colors	.13
C colors	.17
D colors	.20

Diagonal half tile of 9"x9", add 3 cts. per sq. ft. additional.

Feature strips in standard colors are priced at their group price plus 10 cts. per sq. ft. additional.

Standard, die-cut design asphalt tile inserts, size 18"x18", cost about $3.00 each.

"A" colors—Dark red and black solid patterns.
"B" colors—Dark marbleized patterns.
"C" colors—Medium light marbleized patterns.
"D" colors—Light marbleized patterns.

Greaseproof Asphalt Tile

Greaseproof colors are also acid resistant. Standard size 9"x9"

	Price per Square Foot ⅛" Thick	3/16" Thick
Greaseproof Asphalt Tile	$0.24	$0.36

Cost of 100 Sq. Ft. ⅛" Gauge 9"x9" Asphalt Tile Laid Over Concrete Floors

	Hours	Rate	Total	Rate	Total
0.6-gal. asphalt primer		$	$	$1.20	$ 0.72
105 sq. ft. ⅛" tile				.15	15.75
0.5-gal. asphalt cement				1.50	.75
Mechanic	2.4			6.50	15.60
Cost 100 sq. ft.	2.4		$		$32.82
Cost per sq. ft.					.33

*Depends on color.

If concrete primer is not required, deduct asphalt primer, asphalt cement, 0.4-hr. labor and add 0.75-gal. asphalt emulsion.

Cost of 100 Sq. Ft. $\frac{1}{8}$" Gauge 9"x9" Asphalt Tile Laid Over Wood Subfloor

	Hours	Rate	Total	Rate	Total
0.75-gal. resilient tile paste		$.....	$.....	$1.00	$ 0.75
12 sq. yds. lining felt....		.....	.....	.11	1.32
105 sq. ft. $\frac{1}{8}$" tile.....		.....	.....	.15	15.75
0.75-gal. asphalt emulsion		.....	.....	1.10	.83
Mechanic	2.4	.....	.....	6.50	15.60
Cost 100 sq. ft.....	2.4		$.....		$34.95
Cost per sq. ft.....			.....		.35

Vinyl Asbestos Tile

Vinyl asbestos tiles are composed of vinyl resins and asbestos fillers. These tiles are relatively inexpensive, can be used below grade, come in a large variety of colors and designs far superior to asphalt tile and have good durability and low maintenance cost. They are the most widely used floors today.

They are generally available in 9" and 12" squares in $\frac{1}{16}$", $\frac{3}{32}$" and $\frac{1}{8}$" gauges, and range from $0.25 to $0.45 per sq. ft. Installation costs will approximate those of asphalt tile.

Vinyl Plastic Tile.—Vinyl plastic tile is a more expensive resilient flooring material. It is very stable, will not shrink or expand and is highly resistant to oils, fats, greases, acids, alkalis, detergents, soaps and most solvents.

Furnished in 9"x9", 12"x12" and 18"x36" sizes and in $\frac{3}{32}$" and $\frac{1}{8}$" thicknesses.

Subfloor requirements are the same as for other resilient flooring. May also be laid over concrete floors, or on grade or below grade, using special adhesives.

Vinyl plastic tile is laid in the same manner as other resilient tile and labor costs are about the same as for installing asphalt tile.

Material costs vary according to pattern, ranging from 45 cts. per sq. ft. for marbleized patterns to $2.25 per sq. ft. for translucent patterns, for $\frac{1}{8}$" thick tiles. $\frac{3}{32}$" thick tiles cost about 15 to 20 percent less.

The above costs are based on fairly large installations. Small jobs may run 50 percent more than given above.

*Cost of tile varies according to color and thickness.

RUBBER TILE FLOORS AND BASE

Rubber tile are furnished in 9"x9", 12"x12", and 18"x36" tile, $\frac{1}{8}$" thick and in a variety of colors.

Rubber floor tile may be laid over wood or suspended concrete. It may also be laid over clean, dry, concrete floors on ground at or below grade providing a special adhesive, recommended by the manufacturer of the tile, is used.

Wood floors, receiving rubber tile, should be double constructed of tongue and groove lumber or plywood in accordance with flooring manufacturer's recommendations.

When laying rubber tile over an old wood floor, all loose, defective or badly worn boards shall be replaced and face nailed. Any uneveness in the boards shall be planed or sanded smooth and even.

If the wood floors cannot be placed in proper condition by these methods, install Temboard, Masonite or $\frac{1}{4}$" plywood over the original wood floor.

Over the wood base there shall be installed semi-saturated lining felt which shall be securely affixed to the base with linoleum paste. Spread the paste with a paste spreader used for linoleum installations. Depending upon the condition of the subfloor, the spreading capacity should be about 140 sq. ft. per gallon. After the felt is laid, it should be thoroughly rolled with a three-section 100-lb. linoleum roller.

The tile should be installed over the felt, using linoleum paste, spreading the paste as outlined above.

The finished floor should be thoroughly rolled with a three-section 100-lb. linoleum roller and any high edges smoothed in place with a flat headed hammer.

Laying Rubber Tile.—The cost of laying rubber floor tile varies with the size and shape of the room or space where the tile are to be laid, size of tile, kind of subfloor, etc., as it is easier to lay tile in a large square room than one cut up with offsets, pilasters, bays, etc.; the size of the tile, as a man will lay more sq. ft. of large size tile than of the smaller sizes.

When laying lining felt over wood subfloors, an experienced man should spread paste, lay and roll 250 to 300 sq. ft. of felt an hr depending upon the room sizes.

After the felt has been laid (over wood floors), an experienced

tile setter should lay and finish the following sq. ft. of tile of various sizes per 8-hr. day:

Size of Tile	No. Sq. Ft. Laid per 8-Hr. Day	Hours per 100 Sq. Ft.
9"x9"	400—425	2.0
12"x12", 18"x36"	600—675	1.3

The above quantities are based on fair sized rooms. If laid in small spaces, increase labor costs accordingly.

Prices of Rubber Floor Tile, All Standard Colors

Not Installed

Square Edge Floor Tile	Price per Sq. Ft.
⅛" Thick	$0.60

For jobs containing less than 500 sq. ft. add 2 cts. per sq. ft.

For jobs containing more than 2,000 sq. ft. deduct 2 cts. per sq. ft.

Feature strips less than 3" wide, add 15 percent to tile prices.

Tile with cut corners, add 15 percent to tile prices.

Prices on Rubber Composition Top-Set Cove Base

Description	Price per Lin. Ft.
4" base	$0.33
6" base	.35

Corners and end stops available.

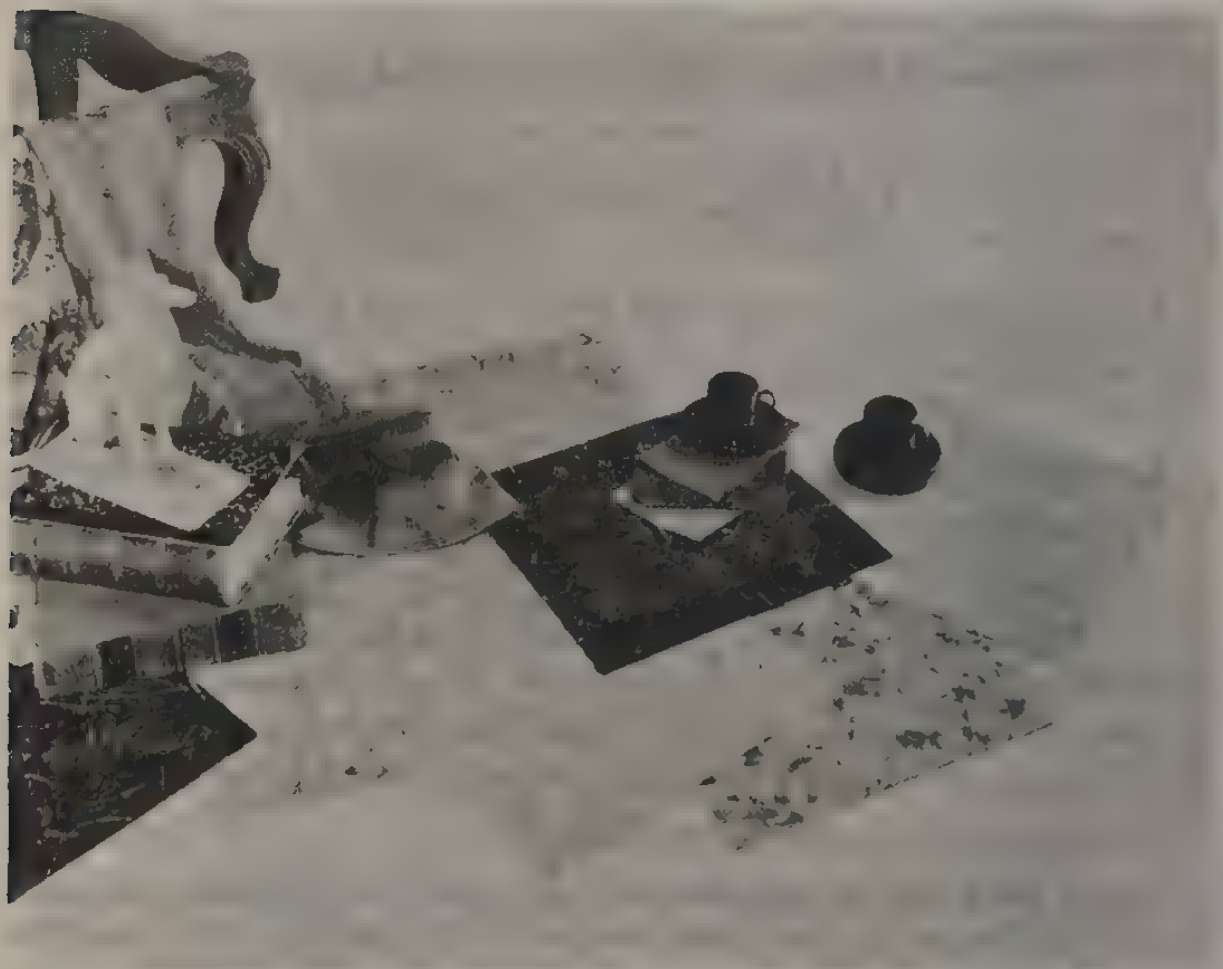
When base and accessories are ordered in quantities of 2,500 lin. ft. or more at one time, deduct 1-ct. per lin. ft. from the above prices.

Cost of 100 Sq. Ft. 9x9-In. Rubber Tile Floors

	Hours	Rate	Total	Rate	Total
12 sq. yds. lining felt		$	$	$0.11	$ 1.32
0.75 gal. adhesive				1.00	.75
102 sq. ft. ⅛" rubber tile				.60	61.20
1 gal. adhesive				1.00	1.00
Mechanic	2.4			6.50	15.60
Cost 100 sq. ft.	2.4		$		$79.87
Cost per sq. ft.					.80

Cost of 100 Lin. Ft. 4-In. Top-Set Rubber Cove Base

	Hours	Rate	Total	Rate	Total
100 lin. ft. 6" base.....		$.....	$.....	$0.33	$33.00
0.75 gal. waterproof cement		.....	.....	3.75	2.81
Mechanic	3	.....	.....	6.50	19.50
Cost 100 lin. ft.....	3		$.....		$55.31
Cost per lin. ft.....					.55



Translucent Vinyl Tile.

CORK TILE

Cork tile are made from high-grade pure cork shavings compressed and baked in molds. It is used for floors and wainscoting in offices, libraries, hospitals, schools and other places where footsteps must be muffled.

They are furnished in 6"x12", 9"x9" and 12"x12" size, $\frac{1}{8}$", $\frac{3}{16}$" and $\frac{5}{16}$" thick. Cork tile are supplied beveled or unbeveled. With unbeveled cork tile, sanding the finished floor is usually necessary to offset uneveness of the subfloor. With beveled cork tile, the

beveling conceals such irregularities, with the result that sanding is unnecessary and the smooth surface given at the tile factory is retained.

Cork tile should never be placed over a single wood subfloor but should be first covered with Temboard, Masonite, ⅜" plywood or 1"x3" D&M kiln-dried flooring. Never install on grade or subgrade floor.

The wood or suspended concrete subfloor must be smooth and even before cork tile can be placed. Lining felt is used over wood subfloors but this is not necessary when applied over smooth, level suspended concrete floors.

After the floor has been laid and sanded (if unbeveled tile are used), the floor should be given a coat of cork tile filler, followed by two coats of cork tile finish (glossy or flat) and subsequent waxings with an approved water emulsion wax, or the floor may be finished by merely applying 3 applications of water emulsion wax and vigorously buffed by machine.

Approximate Square Foot Prices of Cork Tile

Kind of Tile	⅛" Thick	1/16" Thick
Color according to manufacturer's specs., regular sizes	$0.50	$0.80

Border feature strips: In any width under 3" and any length between 18" and 36" at 3 cts. per sq. ft. additional.

Half tile: Cut diagonally from any regular size square tile at 5 cts, per sq. ft. additional.

Factory finished tile: Add 5 cts. per sq. ft. for beveled cork tile finished at factory with sealer, undercoat, and one application of Linoglass wax. After installation, apply one application of Linoglass wax and buff.

Cost of 100 Sq. Ft. 9"x9"x⅛" Cork Tile Floors

	Hours	Rate	Total	Rate	Total
0.75-gal. linoleum paste..		$.....	$.....	$1.00	$ 0.75
12 sq. yds. lining felt.....		.....	.....	.11	1.32
105 sq. ft. cork tile.....		.....	.....	.50	52.50*
0.75-gal. linoleum paste..		.....	.....	1.00	.75
Mechanic	3.5	.....	.....	6.50	22.75
Sanding 100 sq. ft.....		.....	.....	.06	6.00
Finishing Floor					
0.33-gal. cork tile sealer..		.....	.....	1.75	.58
0.25-gal. cork tile undercoat		.....	.....	1.75	.44
0.13-gal. water emul. wax		.....	.....	2.65	.34
Carried Forward			$.....		$85.43

*Cork tile varies according to thickness. For beveled tile, deduct cost of sanding. Over concrete floors, deduct lining felt and paste.

Cost of 100 Sq. Ft. 9"x9"x⅛" Cork Tile Floors—Continued

	Hours	Rate	Total	Rate	Total
Carried Forward		$.....	$.....	$.....	$85.43
Labor clean and wax floor	2.0	.....	.....	5.00	10.00
Cost 100 sq. ft.....	5.5		$.....		$95.43
Cost per sq. ft.....					.95

Cost of 100 Sq. Ft. 12"x12"x⅛" Cork Tile Floors

	Hours	Rate	Total	Rate	Total
0.75-gal. linoleum paste..		$.....	$.....	$1.00	$ 0.75
12 sq. yds. lining felt.....		.....	.....	.11	1.32
105 sq. ft. cork tile.....		.....	.....	.50	52.50*
0.75-gal. linoleum paste..		.....	.....	1.00	.75
Mechanic	2.5	.....	.....	6.50	16.25
Sanding 100 sq. ft.....		.....	.....	.06	6.00
Finishing Floor					
0.33-gal. cork tile sealer..		.....	.....	1.75	.58
0.25-gal. cork tile undercoat		.....	.....	1.75	.44
0.13-gal. water emul. wax		.....	.....	2.65	.34
Labor clean and wax floor	2.0	.....	.....	5.00	10.00
Cost 100 sq. ft.....	4.5		$.....		$88.93
Cost per sq. ft.....			.....		.89

*Cork tile varies according to thickness. For beveled tile, deduct cost of sanding. Over concrete floors, deduct lining felt and paste.

LINOLEUM FLOORS

Linoleum floors are extensively used in offices, residences, kitchens, bathrooms, restaurants, drug stores, etc. This is due chiefly to the improved methods of laying and the attractive patterns produced by the manufacturers.

Inasmuch as linoleum floors are frequently specified for use in new buildings, it is important the contractor be conversant with the various kinds of linoleum, methods of estimating, costs, etc.

What Linoleum Is.—Linoleum is a flooring material having a foundation or back of burlap or saturated felt on which is imposed a body composition which has for its principal binder oxidized linseed oil incorporated with finely ground cork or wood flour, rosin, and various gums and pigments. There are a number of kinds of linoleum made at the present time, each of which is made by a different process and requires a different composition of ingredients in its manufacture.

Linoleum is usually furnished in rolls, 6-ft. wide, up to 90'-0" long and is available in three gauges—service, 1/16" thick; standard, 3/32" thick and heavy, ⅛" thick. All styles, patterns and colors are not available in all gauges.

†Add for overhead expense and profit.

Good Linoleum Laying.—Linoleum may often be ruined by poor laying. Manufacturers have realized this salient fact and have tried to remedy the difficulty. The Armstrong Cork Company has conducted various research studies and investigations for the past thirty years on this problem and has determined certain methods of laying which are recommended to the public and to the linoleum trade. Briefly the recommendations on laying are:

1. To insure that linoleum will give absolute satisfaction on a wood floor, bond it over a lining of semi-saturated felt of approved weight.
2. Do not bond linoleum direct to a wood floor.
3. On suspended concrete, linoleum may safely be bonded direct, without a felt lining, although linoleum is not recommended for concrete floors that are in direct contact with the ground, on or below grade.

Laying Linoleum Over Wood.—Inasmuch as the floor boards in an ordinary wood floor are subject to expansion or contraction due to changing weather conditions, it is not advisable to bond linoleum direct to wood. For a wood base a layer of deadening felt should first be pasted upon it. The felt should be pasted counterwise to the flooring because it will absorb the floor board movement. This method relieves the strain on the linoleum surface and avoids possibilities of the linoleum cracking or bulging under normal conditions. This method of bonding linoleum over a lining of felt has been widely adopted by all progressive linoleum merchants and contract layers. Avoid coinciding seams of felt and linoleum.

Laying Linoleum Over Concrete.—Linoleum may often be cemented direct to dry suspended concrete. However, the concrete must be troweled to a smooth and even finish and be thoroughly dry before application. When concrete has been surfaced with a float finish, with consequent roughness, it is recommended that the linoleum be bonded over a felt lining, in order to insure entire satisfaction. In most installations linoleum paste is used to bond the linoleum to the entire floor area. When felt is used, linoleum paste is applied to both the floor and the felt to bond the felt to the floor and the linoleum to the felt.

Installations in places where the floors will be subject to excess surface moisture should be made in the same way except that waterproof cement is used on the seams and edges to make the floor watertight.

It should be remembered, however, that linoleum should never be bonded directly to a concrete floor which has contact with the ground. It is almost impossible to eliminate moisture

from a basement floor. Moisture on a floor causes mildew or mold, disintegrates linoleum paste, and will in time injure the linoleum.

Estimating Quantity of Linoleum Required.—In estimating the number of strips of linoleum needed to cover the specified spaces, plan to use the waste falling off in one room wherever it will fit to advantage in another. In so doing however, never cause more than one additional seam. Too many seams often spoil a good job. Plan to use your strips of linoleum in such a manner that a minimum number of seams is necessary.

Quantity of Linoleum Paste.—Estimate the quantity of linoleum paste on the basis of one gallon to every 12 to 18 sq. yds. of floor area when bonded direct without felt or 6 to 9 sq. yds. where felt is used. Linoleum paste costs about $1.00 per gal.

Quantity of Waterproof Cement.—Figure 1 gal. of waterproof linoleum cement to every 40 sq. yds. of linoleum, where the cement is used only for seams and edges of linoleum. Price, $3.75 per gal.

Semi-Saturated Lining Felt.—Semi-saturated lining felt is supplied in rolls 36" wide and 50 yds. long. Costs about $5.50 per roll or 11 cts. per sq. yd.

Laying Linoleum Floors Direct to Concrete.—Where linoleum floors are cemented direct to suspended concrete floors without the use of lining felt, a man should lay about 50 sq. yds. per 8-hr. day, at the following cost per 100 sq. yds.:

	Hours	Rate	Total	Rate	Total
Linoleum layer	16		.....	$6.50	104.00
Cost per sq. yd.....			.....		1.04

Laying Linoleum Floors Using Lining Felt.—Where linoleum floors are laid over wood or concrete surfaces, using semi-saturated lining felt, a linoleum layer should lay about 35 sq. yds. per 8-hr. day, at the following cost per 100 sq. yds.:

	Hours	Rate	Total	Rate	Total
Linoleum layer	23	$.....	$.....	$6.50	$149.50
Cost per sq. yd.....		....	.....		1.50

Laying Linoleum Floors Having Borders.—Where linoleum floors have a border of another color, figure the work in the regular way and add about 20 cts. extra per sq. yd. for labor laying the border.

Waxing Linoleum Floors.—After the linoleum floors are laid, they should be waxed 4 to 5 days later, using a good water emulsion wax, as recommended by the linoleum manufacturer. One gallon of wax should cover 200 to 300 sq. yds. of linoleum.

Waxing Linoleum Floors.—If linoleum floors are waxed after laying, a good mechanic and helper can scrub, wax and polish

160 to 175 sq. yds. of floor per 8-hr. day, at the following labor cost per 100 sq. yds.:

	Hours	Rate	Total	Rate	Total
Mechanic	5	$.....	$.....	$6.50	$32.50
Helper	5	.....	.....	5.00	25.00
Cost 100 sq. yds.	10		$.....		$57.50
Cost per sq. yd.			.....		.58

Cost of 100 Sq. Yds. Linoleum Floor Bonded Direct to Concrete Floors

	Hours	Rate	Total	Rate	Total
105 sq. yds. heavy ($\frac{1}{8}$") linoleum		$.....	$.....	$4.00	$420.00
8 gals. linoleum paste		.....	.....	1.00	8.00
2.5 gals. waterproof linoleum cement		.....	.....	3.75	9.38
Linoleum layer	16	.....	.....	6.50	104.00
0.5-gal. wax		.....	.....	2.65	1.33
Mechanic applying wax	5	.....	.....	6.50	32.50
Helper	5	.....	.....	5.00	25.00
Cost 100 sq. yds.	26		$.....		$600.21
Cost per sq. yd.			.....		6.00

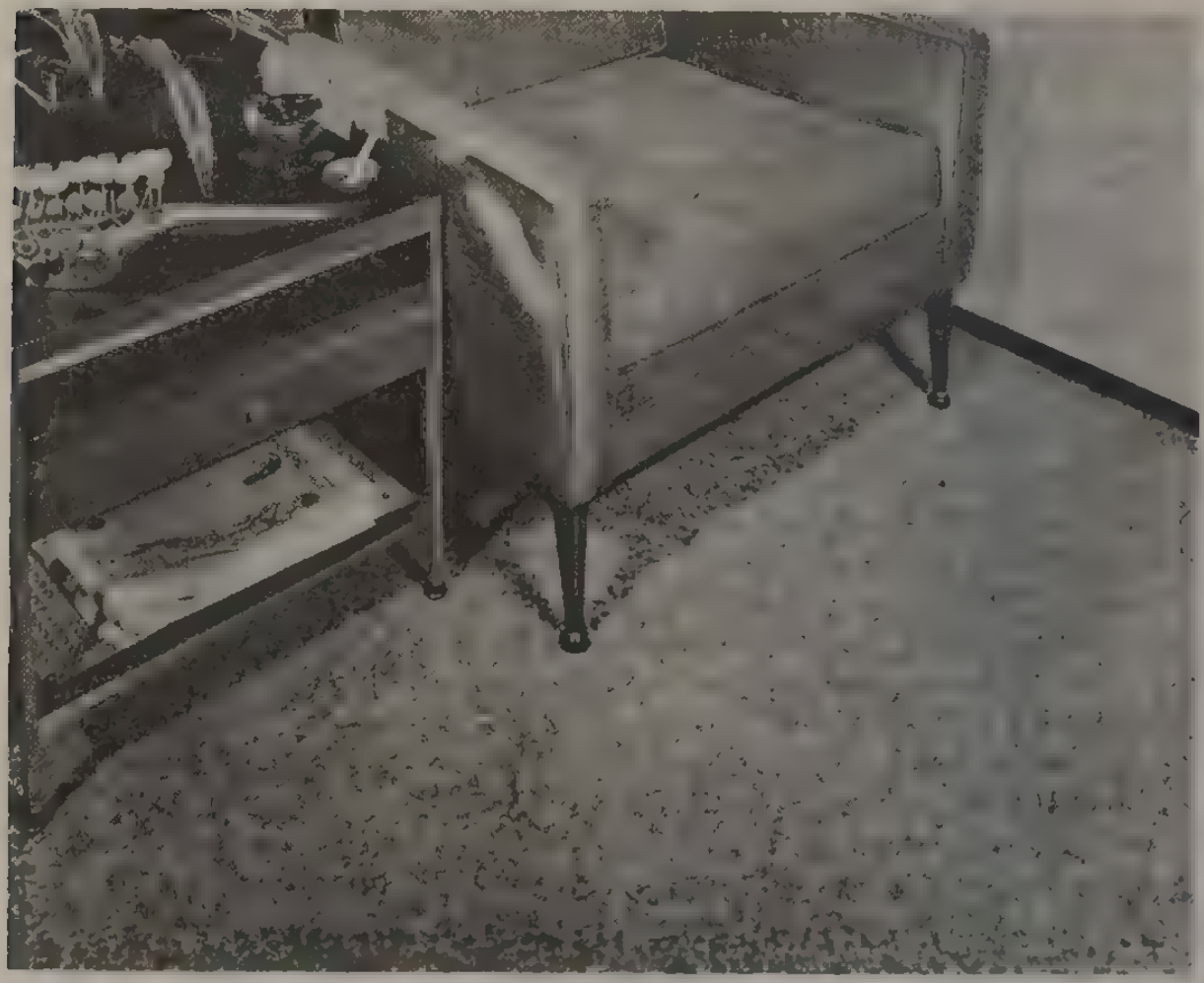
Cost of 100 Sq. Yds. Linoleum Floor Laid Over Lining Felt Bonded to Wood or Concrete Floor Surface

	Hours	Rate	Total	Rate	Total
105 sq. yds. lining felt		$.....	$.....	$0.11	$11.55
105 sq. yds. linoleum*		.....	.....	4.00	420.00
16 gals. linoleum paste		.....	.....	1.00	16.00
2.5 gal. waterproof cement		.....	.....	3.75	9.38
Linoleum layer	23	.....	.....	6.50	149.50
0.5-gal. wax		.....	.....	2.65	1.33
Mechanic applying wax	5	.....	.....	6.50	32.50
Helper	5	.....	.....	5.00	25.00
Cost 100 sq. yds.	33		$.....		$665.26†
Cost per sq. yd.					6.65

*Linoleum cost will vary according to kind and grade selected.
Add 20 cts. per sq. yd. if border is used.
†Add for overhead expense and profit.

VINYL SHEET FLOORING

A vinyl sheet product that is unique in formulation and appearance is Armstrong's Tessera Vinyl Corlon. This product is suitable for heavy-traffic areas, and is made with a hydrocord backing to allow below-grade installation. It is available in three gauges; .090", .070", and .065". Width is 6' and in rolls up to 80' in length. With considerable care and labor, sheet vinyl can be run mono-



Vinyl Sheet Flooring

lithically to form coves and risers. The heavy gauge sheet can be installed in accordance with the Armstrong Perimiflor Installation System so that all seams are sealed.

A new Armstrong development is "Cambrian Vinyl Corlon" with sheet vinyl over ⅛" foam vinyl for greater comfort. Installed costs run from $1.35 to $1.50

PREFABRICATED ACOUSTICAL SYSTEMS

A large variety of prefabricated acoustical products is available on today's market. In general, they fall into three categories: acoustical tiles which are mounted on ceilings, suspended boards, or clipped or splined to suspension systems; acoustical panels for lay-in systems on exposed runners; and metal pan systems for mechanical suspension. Many systems today are also engineered to distribute air and light as well as to control sound; also, some systems are rated as fire resistive assemblies.

Acoustical tile are applied to ceilings and walls for the purpose of absorbing and deadening sound in offices, banks and other spaces where the utmost in quiet is desired, and in auditoriums to obtain optimum reverberation time.

Acoustical tile are made of many different materials, such as wood fiber, cane fiber, mineral wool, cork, specially processed mineral filaments, perforated metal units, and other insulating materials.

They are made in a variety of sizes, such as 12"x12", 12"x24", etc., and vary from ½" to 2" thick, depending upon the materials used.

Acoustical tile may be installed over sound, dry plaster or concrete that is thoroughly seasoned, over gypsum board, or nailed or screwed to 1"x3" wood furring strips or by means of mechanical suspension systems.

If cemented, four spots of cement or adhesive should be applied to each tile on each corner of a 12"x12" tile. The spots should be placed as uniformly as possible with relation to the corners of the tile. A sufficient area on each corner of the tile should be primed prior to the application of the spot to receive the entire spot when it has been pressed to its final diameter. The spots of cement should be applied to these primed areas using a putty knife or trowel. The spot should be approximately the size and shape of a walnut, and should be nearly uniform in size and shape except where thicker spots are required to level surfaces. They should stand out from the tile about ½" to ¾" so as to contact the surface at about the same time. The diameter of the spot when pressed in place should be approximately 2½" to 2¾" and about ⅛" thick.

In placing, the tile should be held with both hands so that when the pressure is applied it will be between the spots rather than outside them. The tile should be held as nearly parallel to its final position as possible and pressed to position with a firm pressure. A slight lateral sliding motion of the hands while setting is necessary to settle the cement into the ceiling surface. It is important that the tile be pressed to level when setting.

A crew of at least two men is required to handle the work of installation efficiently, one man on the scaffold applying the adhesive to the tile and the other man placing the tiles on the ceiling.

One gallon of acoustical cement is sufficient for approximately 60 sq. ft. of tile under average conditions, although this varies somewhat with the surface to which it is applied. Adhesive costs about $1.00 and up, per gallon.

Labor Placing Acoustical Tile.—The labor cost of placing acoustical tile on ceilings will vary with the size of the rooms or spaces where the tile are to be applied, pattern in which the tile are laid, height of scaffolding, etc.

The following quantities are based on 2 mechanics working

together from a 4 to 6-ft. scaffold consisting of horses and planks and laying tile in plain square or ashlar designs:

Size of Acoustical Tile	No. Pcs. Placed per 8-Hr. Day	No. Sq. Ft. Placed per 8-Hr. Day	Hrs. per 100 Sq. Ft. Mechanic
12″x12″	850- 900	850- 900	1.9
12″x24″	450- 500	900-1,000	1.7

When acoustical tile are laid in herringbone pattern, it requires 30 to 40 percent more time than regular squares or common bond. Diagonal patterns require 20 to 25 percent more time than regular squares or common bond, while mixed ashlar designs require about 50 percent more time than straight squares or common bond.

When placing tile in auditoriums and other spaces requiring high scaffolding, the additional cost of the scaffolding will have to be added to the cost of installing the tile.

Large jobs are applied faster proportionately than small jobs.

Erected Prices on Acoustical Tile.—Most acoustical tile jobs are sublet to concerns specializing in this work as they have mechanics experienced in applying their particular brands of tile and can complete the job at less cost than a general contractor who purchases the tile and attempts to install them.

The following are approximate prices on the various classes of tile erected in place on fair size jobs:

Type of Installation	Price per Sq. Ft.
¾″ wood fiber tile cemented to existing ceiling	$0.42
¾″ mineral tile cemented to existing ceiling	.50
¾″ mineral tile on concealed suspension system 12″x24″	.68
⅝″ mineral fiberboards on suspended lay-in system 24″x48″	.40
Metal pan suspended system, 26 ga. steel 12″x24″	1.25
Aluminum 12″x24″	1.45

These prices may be reduced somewhat on large installations.

Cost of 100 Sq. Ft. 12″x12″ Acoustical Tile on Ceilings

	Hours	Rate	Total	Rate	Total
105 sq. ft. acoustical tile		$.....	$.....	$0.30	$31.50*
1.75 gal. adhesive		.....	.....	3.25	5.69
Mechanics	2	.....	.....	6.50	13.00
Cost 100 sq. ft.	2		$.....		$50.19
Cost per sq. ft.			.....		.50

*Cost of tile varies according to kind and thickness.
See note above regarding cost of special furring systems.

Cost of 100 Sq. Ft. 12"x24" Acoustical Tile on Ceilings

	Hours	Rate	Total	Rate	Total
105 sq. ft. acoustical tile...		$.....	$.....	$0.30	$31.50*
1 75-gal. adhesive		.....	.....	3.25	5.69
Mechanics	1.75	.....	.....	6.50	11.38
Cost 100 sq. ft.....	1.75		$.....		$48.57
Cost per sq. ft.....			.....		.49

Metal Pan Type Acoustical Tile.—This type of acoustical treatment consists of metal units 12"x24" in size, having center grooves which result in the appearance of 12"x12" units when applied. The edges, which are beveled and returned vertically, are firmly held in place on the 12" sides by special tee runners. Within the metal units and supported on crimped, galvanized wire mesh, or on miniature channels, are mineral wool absorbent pads.

Costs from $1.00 to $1.50 per sq. ft. installed, depending upon size of job, ceiling height and method of installation.

Suspended systems for lay-in systems consist of hanging wire, angles and tees as manufactured under various patented systems. Installed square foot cost for system only will run 17 cents for 2'x4' grid, 20 cents for 2'x2' grid with exposed systems and slightly more for concealed tees. If carrier channels are required add another 15 cents a square foot.

Allow an additional $25.00 per each 12"x12" access panel required.

Acoustical tile work is simple to estimate, but as it is almost always factory cut and prefinished, it is extremely important to see that job conditions are of the very best, as once installed, there is very little opportunity to "touch up" work. Call backs can quickly eat up profits as well as ruin reputations.

One of the most important conditions to check is temperature and humidity. These should always approximate the interior conditions that will exist when the building is occupied.

All plastering, poured roof decks, concrete and floor work should be complete and dry; all windows and doors in place and glazed. If weather demands it, the building heating, rather than space heating, should be turned on and kept on as though the building were occupied.

Where the contractor, rather than an architect, has the responsibility of choosing types of tile and methods of installation, he should be aware of other factors than just cost. No tile should be applied directly to the underside of a roof deck subjected to sub-

*Cost of tile varies according to kind and thickness.

stantial temperature differences unless the deck is insulated on the top side to minimize expansion and contraction.

The trend today is to square edge tile which minimizes joints. However, tile work will always have slight unevennesses in it and if the job conditions include cove lights or high windows where light strikes the tile surface at a small angle, tile with beveled edges will help conceal any unevenness.

Where tile is to be cemented to a gypsum board backup, the contractor should make sure the board is set on furring strips rather than directly attached to joists to isolate the ceiling from joist movement.

Often, specifications will call for a certain product by trade name followed by "or approved equal." The Acoustical Materials Association, 335 E. 45th St., New York 10017, publishes a bulletin giving performance data for the products of member companies. This can be most helpful in selecting alternate materials for an architect's approval for a substitution.

CHAPTER XXIV

SHEET METAL WORK AND TIN CLAD FIRE DOORS

Sheet metal work in its many branches is a highly specialized business, because the greater part of the work is performed in the shop and the fabricated materials are sent to the job ready to erect. For that reason an estimate on sheet metal work must take into consideration the cost of the finished materials at the shop or delivered to the building site, plus the labor cost of erection.

Estimating Quantities of Sheet Metal Work

The data given on the following pages will assist the estimator in measuring quantities from the plans and listing them on the estimate sheet.

Metal Gutters and Eave Trough.—Metal gutters and eave trough are furnished in numerous designs, from 2″ to 12″ in size. When estimating quantities, obtain the number of pieces of each size gutter and the length of same, as the estimate should state the lin. ft. of each size.

Metal Conductor Pipe or Downspout.—Metal conductor pipe is furnished both round and square and from 2″ to 6″ in size.

When estimating quantities, measure the distance from the roof to the ground, which will be the length of each downspout. After the quantities have been obtained in this manner, list the total number of lin. ft. of each size.

Metal Conductor Heads.—Metal conductor heads are made in various styles, shapes and sizes. They are usually furnished in galvanized steel or copper.

Conductor heads are generally used on buildings having flat roofs where a cast iron conductor pipe is placed inside the building and installed by the plumbing contractor. When placed on the outside of a wall at the roof level, an opening is usually left in the masonry wall at the low point of the roof to allow the water to pass through the wall opening into the conductor head and down the conductor pipe.

When estimating conductor heads always note style and size of each head and the material specified, as there is considerable difference in cost between galvanized steel and copper.

Metal Flashing and Counterflashing.—Flashing and counterflashing is furnished in tin, galvanized steel, aluminum or copper. They are measured by the lin. ft. when less than 12″ wide and by the sq. ft. when over 12″ wide.

Metal flashing used in connection with a flat roof deck covered with felt or built-up roofing usually extends 6″ to 12″ up the side of the brick fire wall and projects under the roofing the same distance. A counterflashing is then placed over and above this flashing. The upper edge of the counterflashing is inserted in a raggle or slot formed in the brick or stone wall. After the counterflashing has been placed, it is caulked with cement mortar or caulking compound to prevent water from getting back of the flashing and running under the roofing.

On many jobs using felt or built-up roofing, the felt is run up the wall about 12″ and mopped. The metal counterflashing is then placed to extend down over the felt, which prevents water from getting back of the flashing and running under the roofing.

Where metal counterflashing is used it is necessary to cut an open joint or raggle in the mortar joint of the masonry wall.

Metal flashing should be estimated by the lin. ft. (stating the width) if less than 12″ wide and by the sq. ft. if over 12″ wide. The kind of metal used should also be stated.

Counterflashing should be estimated by the lin. ft. but the estimate should state the width and kind of metal used.

The cost of cutting raggles should be estimated by the lin. ft.

Metal Valleys and Hips.—Metal valleys and hips are frequently used with certain types of shingle and slate roofs. They are either continuous metal strips of a certain size or small shingles of tin, galvanized steel, aluminum or copper.

They should be estimated by the lin. ft. stating the width of the valley or hip and the kind of metal used.

Metal Ridge Roll, Hip Roll and Cap.—Metal ridge roll, hip roll and cap should be estimated by the lin. ft. giving the width, gauge and kind of metal.

Metal Ventilators.—Metal ventilators for roofs and skylights should be estimated at a certain price for each ventilator, f.o.b. factory or erected. Always state size and type of ventilators required, as there are numerous kinds on the market at varying prices.

Metal Skylights.—When estimating metal skylights, consider the following: Type of skylight, whether single or double pitch or hip skylight; with or without ventilators or side sash; kind of glass, and whether a metal curb flashing is required.

The size of each skylight should be noted, as many firms figure the cost of skylights at a certain price per sq. ft. when they contain over 60 sq. ft. and at a certain price per skylight when they contain less than 60 sq. ft.

Labor Placing Sheet Metal Work

The costs given on the following pages are for the erection of various kinds of sheet metal work on the job. Add cost of the fabricated material, contractor's overhead expense and profit.

Sheet Metal Contractor's Overhead Expense and Profit.—It is customary for general contractors to sublet their sheet metal and cornice work to sheet metal contractors, and for this reason it will be necessary to add a percentage to the actual labor costs to cover rent, office expense, trucking, tools and other items of overhead expense. This will vary with the individual contractor and competitive conditions at the time of letting the contract but a fair average should run from 15 to 25 percent of the actual cost of the work.

The percentage to be added for profit will also vary with the contractor and business conditions as a firm without much work in the shop will figure closer than one that is busy. A fair allowance for a sheet metal contractor's profit should be 10 to 15 per cent of the actual cost of the work.

The total allowance for overhead expense and profit should not exceed 25 to 40 percent of the actual cost.

Placing Hanging Gutter or Eave Trough.—This cost will vary with the slope of the roof, distance above the ground and the method used in hanging the gutter.

On wood constructed buildings having hip or gable roofs, metal hangers or supports are placed over the gutters or eave trough and fastened to the eaves under the shingles or other roofing. The eave trough or gutter must always slope in the direction of the down spout, in order to drain satisfactorily.

On hip or gable roofs having eaves 20′-0″ to 25′-0″ above the ground, a tinner and helper should place 180 to 220 lin. ft. of gutter per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Tinner	4	$.....	$.....	$7.00	$28.00
Helper	4	.....	.....	5.00	20.00
Cost 100 lin. ft.	8		$.....		$48.00*
Cost per lin. ft.			.....		.48

*Add for overhead expense and profit.

Placing Metal Conductor Pipes or Downspouts.—Metal conductor pipes or downspouts are furnished in both round and square and from 1½" to 6" in diameter. The conductor pipe extends down the side of the building from the eaves trough to grade, where it is connected to an elbow that throws the water away from the building or is connected with the drainage system. Metal conductor pipe is usually held in place by hooks fastened to the wood or brick walls.

On one or two story buildings where the conductor pipe is 12'-0" to 25'-0" long, a tinner and helper should place 200 to 250 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Tinner	3.5	$.....	$.....	$7.00	$24.50
Helper	3.5	.....	.....	5.00	17.50
Cost 100 lin. ft.	7.0		$.....		$42.00*
Cost per lin. ft.			.....		.42

Where outside conductor pipe is installed on buildings 3 to 4 stories high, a tinner and helper should place 160 to 200 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Tinner	4.5	$.....	$.....	$7.00	$31.50
Helper	4.5	.....	.....	5.00	22.50
Cost 100 lin. ft.	9.0		$.....		$54.00*
Cost per lin. ft.			.....		.54

Placing Metal Flashing.—When placing metal roof flashing around parapet walls, etc., it is customary to have the flashing extend under the roofing and up the side of the wall 6" to 12", and then place the counterflashing above to protect the flashing.

Where it is not necessary to cut raggles in the masonry wall, a tinner should place 140 to 160 lin. ft. of flashing per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Tinner	5.4	$.....	$.....	$7.00	$37.80*
Cost per lin. ft.			.....		.38

On frame buildings where the flashing extends under the wood wall siding to protect porch roofs, etc., it is only necessary to place the flashing or metal shingles on the roof and tack them against the sheathing. A tinner should place 165 to 185 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Tinner	4.6	$.....	$.....	$7.00	$32.20*
Cost per lin. ft.			.....		.32

*Add for overhead expense and profit.

Placing Metal Counterflashing.—When placing metal counterflashing over felt or metal flashing that extends up the side of the wall, it will be necessary to place the counterflashing in a raggle or open joint in the masonry that can be caulked or sealed to prevent the water getting back of the counterflashing and under the roof.

Where raggles have previously been cut, as is usually the case on stone copings, or where raggle blocks are used, requiring only the sealing of the joint, a tinner should place 140 to 160 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Tinner	5.4	$.....	$.....	$7.00	$37.80*
Cost per lin. ft.					.38

Cutting Raggles in Masonry Walls.—The labor cost of cutting raggles in brick walls will depend entirely upon the kind of mortar used and the condition of the mortar at the time of cutting the raggles.

If the brick are laid in portland cement mortar, it will cost more to cut the raggles than when laid in lime mortar. Also, if the raggles are cut within 24 hrs. after the brick are laid, the labor cost will be much less than cutting them two or three weeks later.

If raggles are cut before the mortar has had sufficient time to set, a man should cut 175 to 225 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Labor	4	$.....	$.....	$5.00	$20.00*
Cost per lin. ft.					.20

If the raggles are cut several days after the brick have been laid, giving the mortar sufficient time to harden, it will require a hammer and chisel to cut out the joints. Under these conditions a man should cut 65 to 80 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Labor	11	$.....	$.....	$5.00	$55.00*
Cost per lin. ft.					.55

If a portable electric saw, having an abrasive blade or cutting wheel is used for cutting the raggles, a man should cut 10 to 15 lin. ft. of raggles an hour.

Cutting raggles in stone coping or balustrade is usually performed by stone cutters at about the same cost as given above.

Placing Metal Valleys.—When placing metal shingles or valleys in connection with gable or hip roofs, dormers, etc., a

*Add for overhead expense and profit.

tinner should place 115 to 135 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Tinner	6.4	$.....	$.....	$7.00	$44.80*
Cost per lin. ft.			.....		.45

Placing Metal Ridge Roll or Cap.—If metal ridge roll is placed on the ridge of a hip or gable roof, a tinner should place 90 to 110 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Tinner	8	$.....	$.....	$7.00	$56.00*
Cost per lin. ft.			.....		.56

Placing Metal Conductor Heads.—On buildings having flat roofs where the conductor pipe or downspout is placed inside of the building, requiring a conductor head at the low point of the roof which is connected to the downspout, a tinner should place one conductor head (made complete in the shop) in 1½ to 2 hrs. at the following labor cost:

	Hours	Rate	Total	Rate	Total
Tinner	1.8	$.....	$.....	$7.00	$12.60*

Erecting and Glazing Metal Skylights.—Metal skylights are manufactured in the shop and sent to the job "knocked down" or in sections ready to erect and glaze.

An average skylight (single pitch, double pitch or hip) up to 8′-0″x12′-0″ in size, containing 100 sq. ft. of area, should be erected and glazed complete by a sheet metal worker and glazier in 8 to 10 hrs. time, at the following labor cost:

	Hours	Rate	Total	Rate	Total
Sheet metal worker	5	$.....	$.....	$7.00	$35.00
Glazier	4	.....	.....	6.10	24.40
Cost per skylight	9		$.....		$59.40*

When erecting skylights 10′-0″x10′-0″ to 10′-0″x15′-0″, containing 100 to 150 sq. ft., a sheet metal worker and glazier should erect and glaze one skylight in 14 to 16 hrs. at the following labor cost:

	Hours	Rate	Total	Rate	Total
Sheet metal worker	9	$.....	$.....	$7.00	$63.00
Glazier	6	.....	.....	6.10	36.60
Cost per skylight	15		$.....		$99.60*

When erecting skylights 10′-0″x16′-0″ to 10′-0″x20′-0″ in size, containing 160 to 200 sq. ft. it will require about 24 hrs. for a sheet metal worker and glazier to erect the skylight and glaze it complete, at the following labor cost:

*Add for overhead expense and profit.

	Hours	Rate	Total	Rate	Total
Sheet metal worker.....	16	$.....	$.....	$7.00	$112.00
Glazier	8	.....	.....	6.10	48.80
Cost per skylight.....	24		$.....		$160.80*

The above costs do not include cost of placing a metal curb flashing for skylight. For costs on this work, see below.

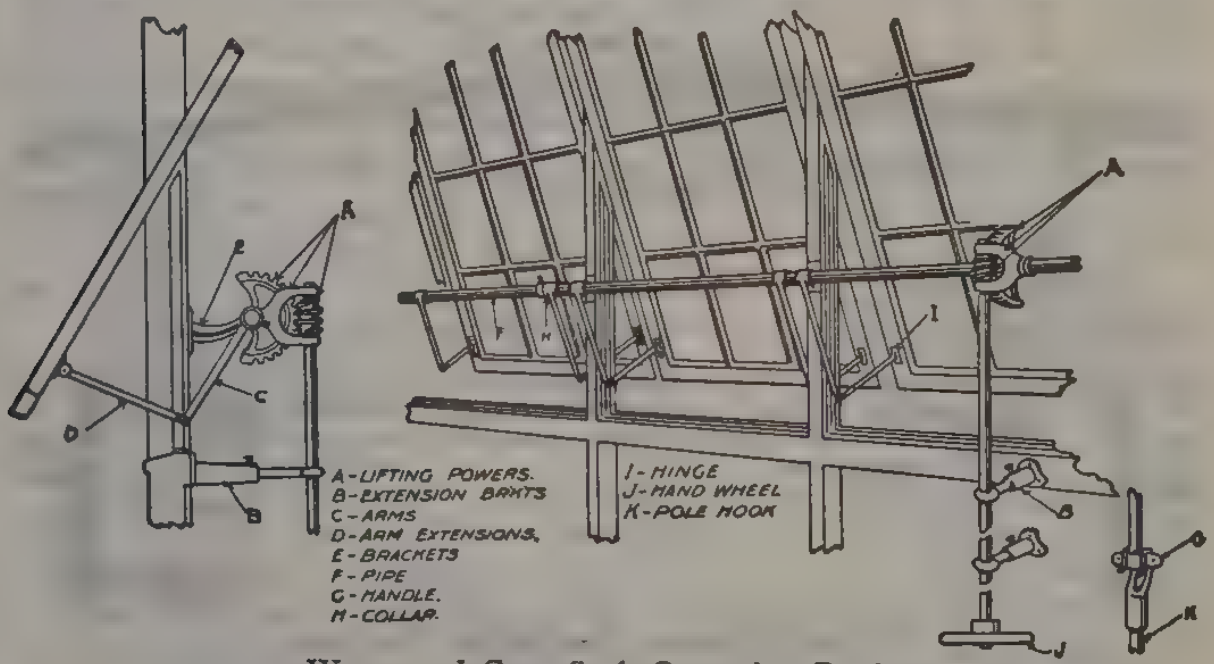
Placing Metal Skylight Curb Flashing.—Metal skylights are often placed on top of a wood curb projecting 6″ or more above the roof level. The space from the top of the curb to the roof level is covered with metal flashing.

When erecting metal skylight curb flashing, a tinner should place 190 to 210 sq. ft. of metal per 8-hr. day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Sheet metal worker.....	4	$.....	$.....	$7.00	$28.00*
Cost per sq. ft.....					.28

Erecting Skylights With Side Sash.—If the skylights have side sash, the erection cost will vary with the number of sash in the skylight and whether stationary or pivoted. On an average it will require 1 to 1½ hrs. labor time for each sash in the skylight, at the following labor cost per sash:

	Hours	Rate	Total	Rate	Total
Sheet metal worker.....	1.25	$.....	$.....	$7.00	$8.75*



Worm and Gear Sash Operating Device

Erecting Sash Operating Devices for Movable Sash.—Skylights furnished with hinged or pivoted sidewall sash require an operating device to open and close them.

*Add for overhead expense and profit.

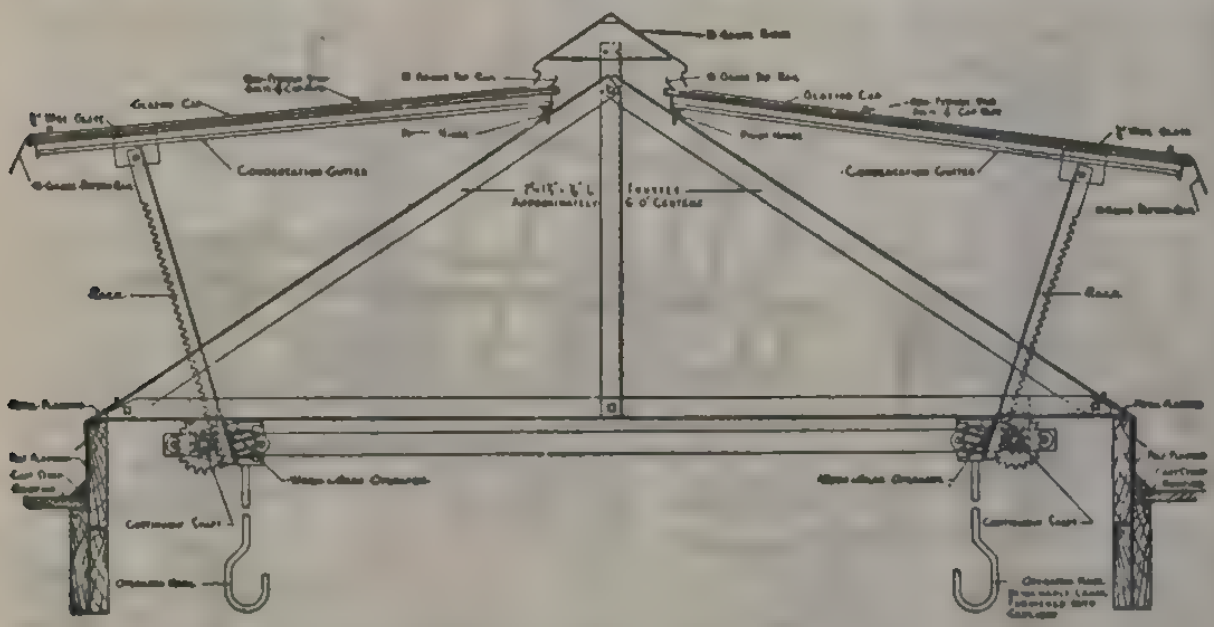
An operating device usually consists of a mechanism similar to that illustrated, which is operated from the floor by a worm and gear or a chain attachment, from which all sash on each side of the skylight can be opened and closed.

The labor cost of erecting sash operating devices will vary with the length of each run and the number of runs in each skylight but on an average, a man should erect 50 to 75 lin. ft. per 8-hr. day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Sheet metal worker.....	13	$.....	$.....	$7.00	$91.00*
Cost per lin. ft.....					.91

*Add for overhead expense and profit.

Ventilating Skylights.—Ventilating skylights are used in factories, foundries, machine shops, garages, dairies, laundries and in any other type of building requiring economical light and ventilation. They are furnished in any type of metal desired, galvanized copper-bearing steel, aluminum or copper, depending upon the nature of the building on which they are to be used. Normally, for building of ordinary construction, the standard 18-gauge galvanized copper-bearing steel is furnished. Should the building be of reinforced concrete or steel and concrete construction, the non-corrosive aluminum or copper construction should be furnished.



Section Through Ventilating Skylight

These skylights are of gable type as illustrated and are furnished in standard widths of 4'-0" to 20'-0" and any desired length in multiples of 2'-0". Standard widths in multiples of 2'-0" are usually carried in stock to facilitate prompt delivery. It is standard practice to interpret the size of a skylight as be-

ing outside to outside of curb dimensions.

The length of the ventilating sections depend upon the width of the skylights; 4′-0″, 6′-0″ and 8′-0″ widths having maximum ventilating sections of 40′-0″ each controlled from one operating station; 10′-0″ and 12′-0″ wide skylights have maximum ventilating sections of 30′-0″ in length; 14′-0″ and 16′-0″ widths have 40′-0″ maximum lengths, and 18′-0″ and 20′-0″ widths have 30′-0″ maximum ventilating sections.

A mechanical operating device consisting of either loose rod or chain control is furnished as required, so that the skylight can be readily controlled from the floor. All skylights under 30′-0″ in length are arranged for full length ventilation. Longer skylights are arranged with ventilating sections as required.

The cost of ventilating skylights vary with their size and number of ventilating sections in each skylight. Small skylights under 6′-0″ wide and from 4′-0″ to 30′-0″ long containing one ventilating unit on both sides, constructed of 18 gauge galvanized copper bearing steel and glazed with ¼″ ribbed wire glass, will cost from $5.00 to $10.00 per sq. ft. Skylights 6′-0″ to 8′-0″ wide and up to 30′-0″ long will cost $5.00 to $7.00 per sq. ft. Skylights 10′-0″ to 12′-0″ wide will cost $4.00 to $6.00 per sq. ft. Skylights over 12′-0″ in width will cost from $5.00 to $7.50 per sq. ft. Where skylights are glazed with heat absorbing glass, add about 40 cts. per sq. ft. Where skylights are glazed with glass that is heat absorbing and glare reducing, add about 75 cts. per sq. ft. The above prices are based on installation in Chicago.

For jobs in other locations, add freight and installation costs. The skylights weigh approximately 10 lbs. per sq. ft. including glass, and the installation costs will vary in accordance with the flat horizontal area of the skylight from 85 cts. to $1.20 per sq. ft.

Puttyless glazing, consisting of the glass being bedded between layers of impregnated asphalt felt, with the glazing assembly secured with brass stud bolts and cap nuts, costs about 18 cts. per sq. ft. additional.

In estimating the cost of ventilating skylights, the principal thing to remember is: The smaller the area of the skylight, the higher the price per sq. ft.

Plastic Dome Skylights.—This type skylight consists of a thermo-formed acrylic plastic sheet free blown into square, rectangular and circular domes.

This type skylight is furnished as a factory assembled unit; the plastic is mounted in an extruded aluminum frame, and prefabricated curbs are available. The aluminum frame is generally designed to form counterflashing.

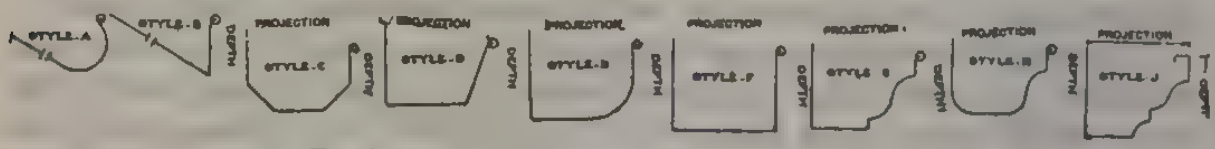
CURRENT PRICES OF SHEET METAL PRODUCTS

The following sheet metal prices are factory prices, f.o.b. Chicago, so freight or trucking should be added.

Prices on Standard Metal Gutters

The metal gutters shown in the accompanying illustration are of standard design, but when ordering same it will be necessary to state the girth of the gutter and the gauge of the material.

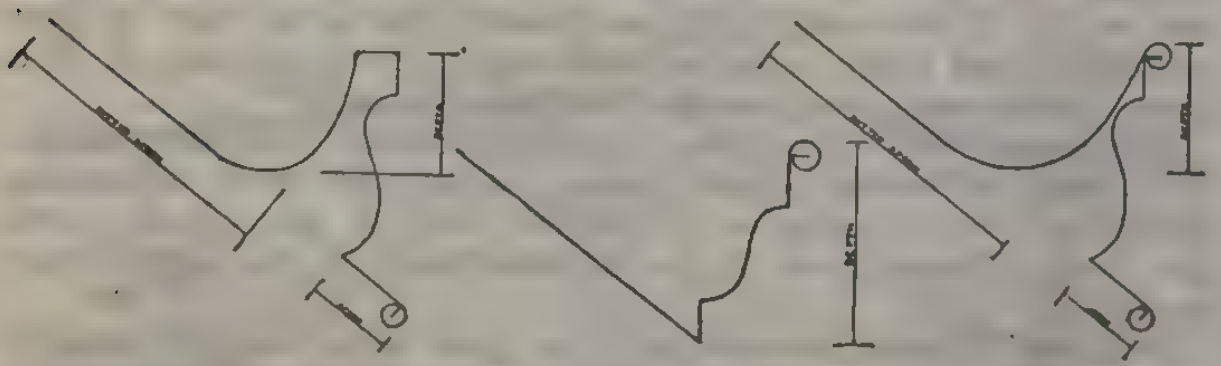
When ordering miters always state whether inside or outside miters are wanted.



Designs of Standard Metal Gutters

Lineal Foot Prices of Standard Galvanized Metal Gutters

Gauge Metal	Girth of Gutter in Inches 12	14	16	18	20	24
26	$0.24	$0.30	$0.35	$0.40	$0.50	$0.59
24	.33	.41	.50	.58	.67	.76



Molded Face Gutter — Ogee Gutter — Molded Face Gutter

Prices of Molded Face Gutters of Galvanized Metal

Gauge Metal	Girth of Gutter in Inches 18	20	24	28	30
26	$0.57	$0.62	$0.72	$0.86	$0.92
24	.68	.77	.90	1.08	1.15

Lineal Foot Prices of Galvanized Ogee Roof Gutters

Gauge Metal	Girth of Gutter in Inches 12	14	16	18	20	24
26	$0.36	$0.45	$0.53	$0.58	$0.73	$0.87
24	.50	.60	.75	.85	1.00	1.18

Prices of Galvanized Steel Eaves Trough, Lap Joint, Single Bead

Gauge Metal	Size in Inches 4	5	6	7
28	$0.14	$0.15	$0.20	$0.33
26	.17	.18	.25	.36
24	—	.30	.35	.42

For slip joint eaves trough add 2 cts. per lin. ft.

Galvanized Steel Eaves Trough.

Prices of Galvanized Steel Eaves Trough, Lap Joint, Double Bead

Gauge Metal	Size in Inches 4	5	6	7
28	$0.15	$0.18	$0.25	$0.38
26	.19	.22	.31	.44
24	—	.37	.42	.47

For slip joint eaves trough add 2½ cts. per lin. ft.

Prices of One Piece Miters for Galvanized Steel Eaves Trough

Gauge Metal	Size in Inches 4	5	6	7
28	$0.75	$0.80	$1.10	$1.42
26	.80	.90	1.19	1.58

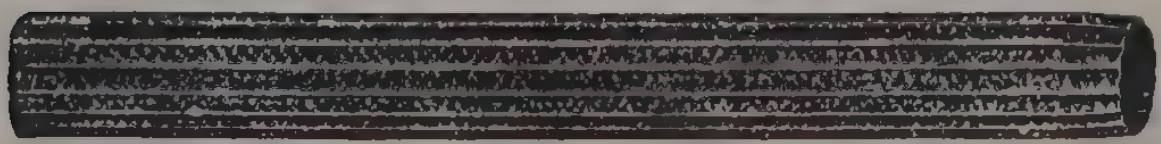
If wanted with single bead and slip joint add 25 cents each.
If wanted with double bead and lap joint, add 25 cents each.
If wanted with double bead slip joint, add 50 cents each.

End Pieces for Metal Eaves Trough.

Miters for Metal Eaves Trough.

Prices of Galvanized Conductor Pipe, Round or Corrugated

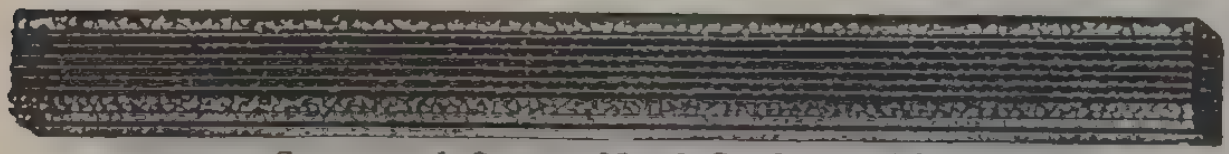
Gauge Metal	Size in Inches 3	4	5	6
26	$0.18	$0.25	$0.33	$0.45
24	.30	.40	.53	.63



Corrugated Galvanized Steel Conductor Pipe.

Prices of Galvanized Steel Conductor Pipe, Corrugated Square

Gauge Metal	Size in Inches 2⅜x3¼	2¾x4¼	3¾x5
26	$0.22	$0.28	$0.42
24	.40	.42	.58



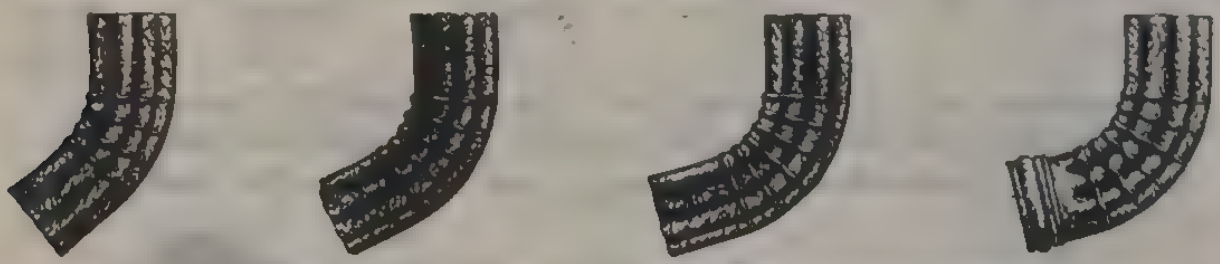
Corrugated Square Metal Conductor Pipe.

Prices of Galvanized Elbows and Shoes, Plain Round and Corrugated

		Size in Inches 2	3	4	5	6
Galvanized Steel Elbows	26 Ga.	$0.30	$0.38	$0.63	$1.45	$1.88
Galvanized Steel Shoes	26 Ga.	.45	.58	.90	1.60	2.25

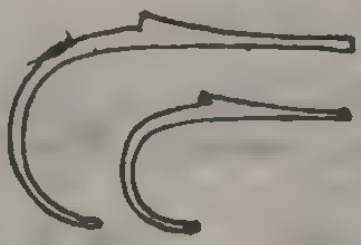
Prices of Square Corrugated Galvanized Steel Elbows and Shoes

		Size in Inches 2	3	4	5
Galvanized Steel Elbows	26 Ga.	$0.45	$0.53	$0.90	$1.75
Galvanized Steel Shoes	26 Ga.	.65	.80	1.40	2.40



Elbows and Shoes for Metal Conductor Pipe

Square Corrugated Conductor Shoes



Malleable Conductor Hooks

Galvanized Wire Conductor Strainers

Prices of Galvanized Steel Cut-Offs, Plain Round and Corrugated

Metal Gauge	Price Each—Size in Inches 3	4	5	6
26	$1.20	$1.55	$2.80	$3.40

Prices of Galvanized Wire Conductor Strainers

Price Each—Size in Inches

2	3	4	5	6
$0.18	$0.20	$0.26	$0.40	$0.45

Prices of Malleable Conductor Hooks

Price Each—Size in Inches

	2	3	4	5	6
Wood	$0.13	$0.20	$0.23	$0.35	$0.52
Brick	.15	.22	.29	.44	.60

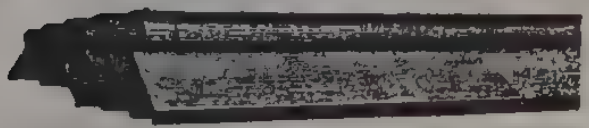
Standard Steel Eaves Trough Hangers.

Standard Wire Eaves Trough Hangers.

Prices of Eaves Trough Hangers

	Size in Inches 4	5	6	7
Wire Hangers, each	$0.08	$0.08	$0.09	$0.10
Steel Hangers, each	.13	.14	.16	.17

Prices of Galvanized Ridge and Hip Roll and Ridge and Hip Cap



Gauge Metal	Girth in Inches 8	10	12
28 Price per lin. ft.	$0.15	$0.17	$0.20
26 Price per lin. ft.	.19	.20	.25

Prices of Galvanized Formed and Rolled Valley

Gauge Metal	Girth in Inches 12	14	16	20	24	30
28	$0.19	$0.24	$0.30	$0.35	$0.45	$0.55
26	.22	.30	.35	.42	.50	.60

Copper Work

Prices for copper have risen considerably recently and the estimator should check all items for local variations. The following prices are based on minimums of 100 ft. of conductor, 100 pieces for fittings. Add 10% for broken cartons. Copper may be lead coated at 40% additional charge.

Lineal Foot Prices of 16-oz. Copper Box Gutters

	Size and Girth of Gutter in Inches			
	4—10	5—12	6—15	7—18
Bundled	$1.13	$1.35	$2.40	$3.20
Crated	1.25	1.55	2.60	3.40

Prices of 16-oz. Copper Box Gutter Fittings

Description	Size in Inches		
	4	5	6
Corners, inside or outside	$2.60	$3.20	$4.85
End caps	.55	.59	.64
Outlets	.72	.98	1.14
End piece with outlet	2.35	2.70	5.75
Hangers	.45	.56	.60

Lineal Foot Prices of 16-oz. Copper Half-round Eaves Trough

	Size of Eaves Trough in Inches		
	4	5	6
Bundled	$1.00	$1.10	$1.35
Crated	1.10	1.20	1.45

Prices of 16-oz. Copper Half-round Eaves Trough Fittings

Description	Size in Inches		
	4	5	6
Corners, inside or outside	$1.90	$2.35	$5.20
End caps	1.00	1.25	1.55
Outlets	.60	.66	.74
End piece with outlet	1.75	2.18	3.80
Hangers, incl. shanks or plates	.60	.68	.80

Lineal Foot Prices of 16-oz. Copper Corrugated or Plain Round Conductor Pipe

	Size in Inches				
	2	3	4	5	6
Loose	$1.00	$1.05	$1.38	$1.90	$2.75
Crated	1.10	1.15	1.45	2.00	2.85

Prices of 16-oz. Copper Conductor Pipe Fittings

Description	Size in Inches				
	2	3	4	5	6
Elbows, corrugated or plain round	$1.50	$1.65	$2.70	$ 5.00	$ 7.80
Shoes, corrugated or plain round	1.60	1.75	2.80	6.10	8.50
Elbows, corrugated square	1.52	1.75	2.72	7.30	...
Shoes, corrugated square	1.55	1.78	2.85	8.50	...
Funnels	2.05	2.50	3.00	...	...
Cutoffs, corrugated or plain round	5.10	5.40	6.80	12.00	14.50

Prices of 16-oz. Copper Conductor Pipe Fittings—Continued

	Sizes in Inches 2	3	4	5	6
ronze conductor hooks for wood....	$0.20	$0.32	$0.46	$0.70	$....
ronze conductor hooks for brick....	.25	.36	.50	.75	1.05
rnamental pipe bands, square.....	...	.63	.63	...	...
onductor strainers, round.....	.25	.43	.57	1.00	1.15
onductor strainers, square.....	.45	.55	1.03	1.30	...

Lineal Foot Prices of 16-oz. Copper Corrugated Square Conductor Pipe

	Size in Inches 2	3	4	5
oose	$1.10	$1.20	$1.55	$2.70
rated	1.15	1.25	1.60	2.78

Prices of 16-oz. Copper Ridge Roll, Valley and Flashing

Description	Price
lain ridge roll, 1½" roll, 8" girth.....	$1.10 per lin. ft.
lain ridge roll, 2" roll, 10" girth.....	1.15 per lin. ft.
lobe finials, 1½".....	2.50 each
lobe finials, 2".....	2.90 each
ormed valley, 16" girth.....	2.40 per lin. ft.
ormed valley, 20" girth.....	2.70 per lin. ft.

Aluminum Eaves Trough, Conductor Pipe and Fittings

Aluminum is non-rusting, light in weight but it must be used ith slip joints as it cannot be soldered.

Description	Gauge		Price
aves trough, single bead, slip joint...	.027"	Lin. Ft..	$0.34
ox Gutter, 5".....	.027"	Lin. Ft...	.35
onductor Pipe or Down Spout, 3" Round	.020"	Lin. Ft...	.23
onductor Pipe or Down Spout, 3" Corrugated Rd.....	.020"	Lin. Ft..	.27
onductor Pipe or Down Spout, 2⅜"x3¼" Sq.	.020"	Lin. Ft..	.27
lbows for Round or Corr. D.S.....	.020"	Each	.48
lbows for Sq. Down Spouts.....	.020"	Each	.50
orners or Miters, Inside or Outside, for Half-round Eaves Trough.....	.027"	Each	.98
orners or Miters, Inside or Outside, for Box Gutter.....	.027"	Each ...	1.31
nd Caps	.027"	Each	.23

Aluminum Eaves Trough, Conductor Pipe and Fittings—Cont'd

Description	Gauge		Price
Strap Hangers, 5" aluminum with 12" shank		Each	$0.2
Connections, Slip Joint, Half-round	.027"	Each	.2
Connections, Slip Joint, Box-type	.027"	Each	.4
Funnels, for 3" Conductor Pipe	.020"	Each	1.1
Aluminum Sheets for Flashings	.019"	Sq. Ft.	.2
Wire Pipe Strainers for 3" Conductor Pipe		Each	.4
Drop Outlets, 5"x3"	.020"	Each	.8

Aluminum copings will run around $3.30 for a 12" wall.

Prefabricated Aluminum Vents

Attic Vent	12"x18"	$2.80
	14"x24"	4.10
	24"x30"	8.00
Eave Vent	4"x16"	.60
	8"x16"	.72
	8"x48"	2.40
Ridge Vent		.58 lin. ft.

Approximate Prices of Metal Skylights

Prices of fixed sash metal skylights (galvanized sheet metal) glazed with ¼" ribbed wire glass.

Size in Feet	Hip	Gable	Size in Feet	Hip	Gable
2x 4	$ 53.00	$ 46.00	6x 6	$ 98.00	$ 96.00
2x 6	75.00	63.00	6x 8	129.00	126.00
3x 4	75.00	63.00	6x10	162.00	158.00
3x 5	88.00	72.00	6x12	196.00	187.00
3x 6	99.00	81.00	6x14	227.00	215.00
3x 8	116.00	101.00	8x 8	172.00	167.00
4x 4	88.00	75.00	8x10	215.00	205.00
4x 5	97.00	86.00	8x12	260.00	250.00
4x 6	100.00	89.00	8x14	304.00	295.00
4x 8	126.00	110.00	8x16	345.00	340.00
4x10	150.00	132.00	10x10	270.00	265.00
5x 5	93.00	87.00	10x12	325.00	314.00
5x 6	103.00	97.00	10x14	380.00	365.00
5x 8	148.00	124.00	10x16	430.00	425.00
5x10	158.00	152.00	10x18	486.00	480.00
5x12	190.00	186.00	10x20	540.00	525.00

Add for ventilators according to design and size, as given on

llowing pages. Add 15% for aluminum. Prices do not include rection.

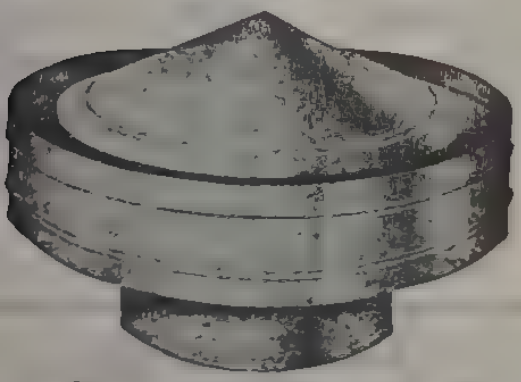
Plastic Domes

Size	Cost Per Roof Dome	Cost With Ceiling Liner
16"x16"	$ 22.00	$ 38.00
24"x24"	30.00	55.00
36"x36"	42.00	75.00
48"x48"	80.00	140.00
24" Round	70.00	110.00
48" Round	135.00	210.00

PRICES OF METAL VENTILATORS

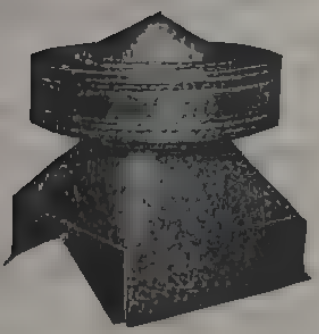
The following prices are given on metal ventilators made of alvanized open hearth steel of substantial gauges.

The glass used in Styles "B" and "C" is ¼-inch ribbed wire ass.



Ventilator Style "A."

Style "B."



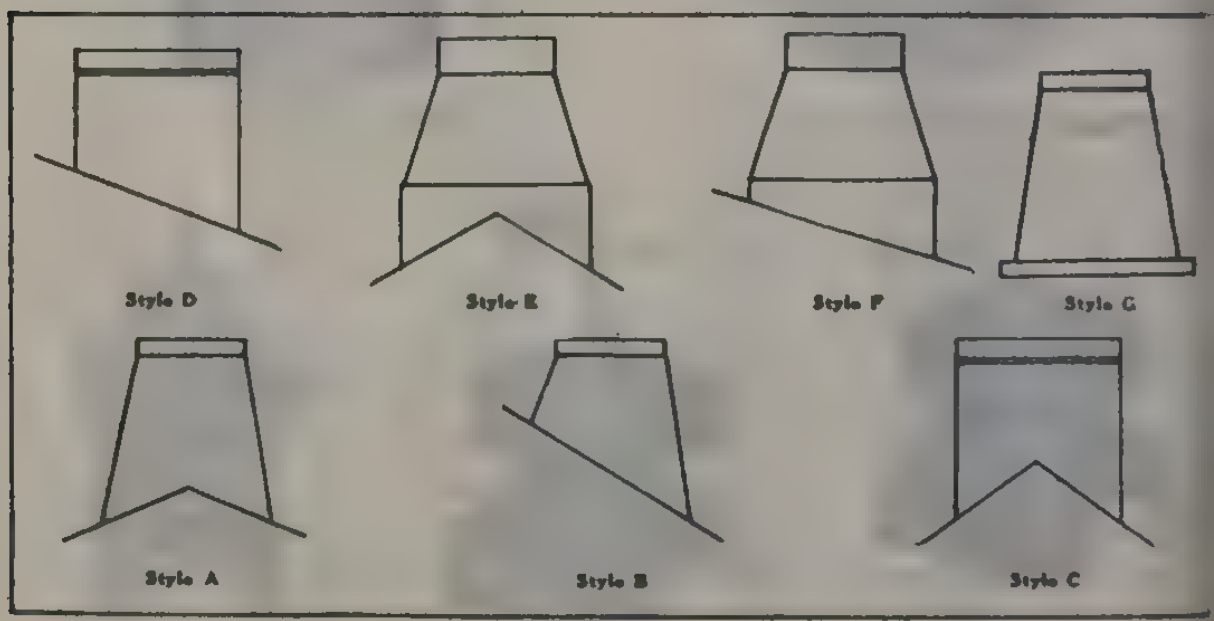
Style "C."

Style "D."

Style "E."

Approximate Prices of Metal Ventilators

Diameter Neck	Ventilators Style "A"	Ventilators Style "B"	Ventilator Bases A-B-C-D	Ventilator Bases E-F-G
6-inch	$ 10.00	$	$ 6.50	$ 8.7
7-inch	11.00	....	$ 6.50	$ 8.7
8-inch	11.00	....	6.50	8.7
9-inch	12.00	....	6.50	10.0
10-inch	13.25	....	6.50	10.0
12-inch	14.50	21.00	7.50	11.0
14-inch	16.50	30.00	8.75	11.0
16-inch	19.00	31.00	10.00	12.0
18-inch	21.00	33.00	12.00	15.5
20-inch	23.00	36.50	14.50	16.5
24-inch	32.00	43.00	16.50	19.0
28-inch	38.50	53.00	16.50	21.0
30-inch	44.00	60.00	16.50	22.0
34-inch	50.00	77.00	18.50	22.0
36-inch	50.00	83.00	18.75	26.5
40-inch	66.00	110.00	22.00	29.0
48-inch	94.00	138.00	27.50	39.0
60-inch	165.00	205.00	44.00	55.0
72-inch	210.00	275.00	55.00	75.0



Ventilator Bases

Approximate Prices on Ventilators "C" and "D"

Diameter Neck	Style "C"	Style "D"	Diameter Neck	Style "C"	Style "D"
16-inch	$33.00	$40.00	30-inch	$ 83.00	$ 88.00
18-inch	37.50	45.00	36-inch	110.00	116.00
20-inch	43.00	52.00	40-inch	142.00	150.00
24-inch	55.00	60.00	44-inch	165.00	165.00
28-inch	72.00	77.00	48-inch	170.00	170.00

Approximate Prices on Ventilator "E"

Size	Price	Size	Price
2'-0"x2'-0"	$132.00	4'-0"x4'-0"	$230.00
2'-6"x2'-6"	154.00	4'-6"x4'-6"	250.00
3'-0"x3'-0"	194.00	5'-0"x5'-0"	275.00
3'-6"x3'-6"	220.00		

Above prices do not include dampers. For dampers 6" to 12" add $2.25; sizes 14" to 24" add $4.00; sizes 28" to 40" add $5.50 and sizes 48" to 72" add $10.00.

Approximate Prices on Revolving Suction Ventilators

Diameter Neck	Price Each	Diameter Neck	Price Each
10-inch	$38.50	24-inch	$100.00
12-inch	44.00	30-inch	140.00
14-inch	50.00	36-inch	190.00
16-inch	62.00	42-inch	270.00
18-inch	72.00	48-inch	300.00
20-inch	77.00		

Sheet Metal Duct Work.—When figuring sheet metal work in connection with heating and ventilating ducts, the cost will vary with the price of metal, location of ducts and scale of wages paid but with galvanized metal at a price of approximately 16 cts. per lb., ordinary duct work will cost about $1.25 to $1.40 per pound, installed, with a wage of $8.00 per hour. Actual duct prices will vary widely according to the number of fittings, transitions, and elbows as well as the size of the job.

TIN CLAD FIRE DOORS

Tin clad fire doors are used in factory, mill and warehouse buildings and may be either sliding or swinging, having fusible links and automatic closing devices.

Sliding doors and lap type swinging doors in brick walls do not ordinarily require a steel frame but they may be necessary with tile walls. Flush type swinging doors require a frame.

Standard 3-ply ($2\frac{5}{8}$" thick) doors are ordinarily used but 2-ply ($1\frac{3}{4}$" thick) are also furnished.

Method of Calculating the Area of Fire Doors.—For flush

doors, multiply the width of the opening in feet by the height of the opening in feet.

Square top lap doors. Obtain size of door by adding 8" to width and 4" to height of opening, then multiply width of door in feet by height of door in feet.

Inclined top lap doors. Obtain width of door by adding 8" to width of opening and obtain height by adding 8" to height of door for doors up to 4'-0" wide and 12" for doors up to 6'-0" wide. Multiply width of door in feet by height of door in feet.

Prices of Tin Clad Fire Doors and Shutters

Price includes door only, covered both sides with tin of a quality and in a manner specified by the National Board of Fire Underwriters.

	Price per Sq. Ft.
Standard 3-ply (2⅝" thick), Wt. 13 lbs. per sq. ft.....	$2.40
Standard 2-ply (1¾" thick), Wt. 10 lbs. per sq. ft.....	2.20
Standard 2-ply (1¾" thick), Shutters, Wt. 10 lbs. per sq. ft..	2.20

Above prices include doors only, no hardware or fixtures of any kind or delivery costs.

Hardware for Swinging, Automatic Closing Tin Clad Doors

Fixture sets include hinges, pintles, weights, chains, catches, latches, complete automatic device with bolts and screws for attaching. Installation not included. Door frames not included.

Door Width Up to and Including	Door Height	Single Swinging Doors Flush Type	Single Swinging Doors Lap Type	Double Swinging Doors Flush Type	Double Swinging Doors Lap Type
3'-0"	x 6'-6"	$ 62.00	$ 81.00	$138.00	$159.00
3'-0"	x 8'-6"	76.00	103.00	157.00	187.00
3'-0"	x10'-6"	91.00	123.00	177.00	211.00
4'-0"	x 6'-6"	64.00	84.00	140.00	161 00
4'-0"	x 8'-6"	79.00	106.00	160.00	189.00
4'-0"	x12'-0"	95.00	128.00	180.00	215.00
5'-0"	x 6'-6"	67.00	86.00	142.00	164 00
5'-0"	x 8'-6"	82.00	110.00	163.00	193.00
5'-0"	x12'-0"	99.00	132.00	184.00	222 00
6'-0"	x 6'-6"	71.00	89.00	145.00	166 00
6'-0"	x 8'-6"	86.00	113.00	166.00	196 00
6'-0"	x12'-0"	104.00	136.00	189.00	223.00

If automatic controls are not wanted with swinging tin clad doors, deduct from the above prices, $8.00 for single doors and $12.00 per opening for double swinging doors.

Hardware for Sliding Tin Clad Doors

Prices include non-adjustable hangers, track, weights and bolts for attaching hardware to doors. Through wall bolts not included.

Hardware for single sliding door, 3′-0″ wide opening	$ 80.00
For each 6″ additional width of opening, add	2.00
Openings over 6′-0″ wide require 3 hangers on each door, add for each additional hanger	8.00
Hardware for double sliding doors, 6′-0″ wide opening	170.00
For each 6″ additional width of opening, add	4.00

Steel Frames for Tin Clad Fire Doors

The following prices cover frames made of structural shapes including standard ¾″x¾″ bar stops, lugs for attaching heads to jambs and adjustable anchors for holding frames in masonry.

Frame Stock	Price per Lin. Ft.	Weight per Lin. Ft.	Approx. Price per Pound
3 ″x 3″ x¼″ Angle	$2.66	6.8 lbs.	$0.39
3½″x 3½″x¼″ Angle	2.79	7.7 ″	.34
4 ″x 5.4 lb. Channel	3.00	7.3 ″	.42
5 ″x 6.7 lb. Channel	3.10	8.6 ″	.37
6 ″x 8.2 lb. Channel	3.45	10.1 ″	.34
8 ″x11.5 lb. Channel	4.10	13.4 ″	.31
9 ″x13.4 lb. Channel	4.55	15.3 ″	.30
10″x15.3 lb. Channel	5.32	17.2 ″	.31
12″x20.7 lb. Channel	7.10	22.6 ″	.32

Standard astragals for double swinging doors, per lin. ft. $0.80

Labor Erecting Tin Clad Doors

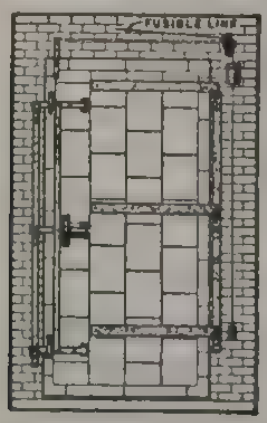
The following schedules are guides for estimating labor for erection furnished us by the Richmond Fireproof Door Co.

The hours of labor are based on brick walls 13″ thick. For walls greater in thickness, add ¼ hour for one man for each 4″ in thickness per bolt involved. Concrete and stone walls require slightly more time drilling; terra cotta, slightly less. Where "doors both sides" are noted, this assumes doors back to back and bolted together. When fixtures cannot be bolted together use "one side" schedule multiplied by two.

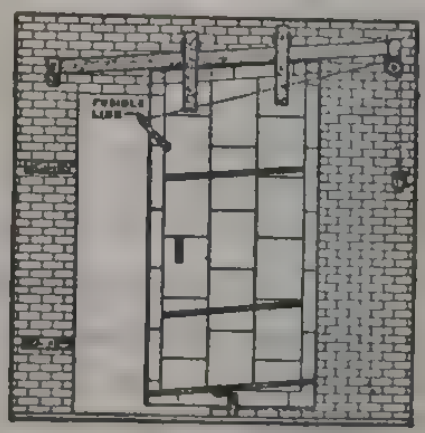
Type	Width	Labor Door One Side Mech.	Help.	Doors Two Sides Mech.	Help.
Single Slide	2′-0″ to 4′-8″	7	7	10	10
	4′-0″ to 5′-2″	8	8	12	12
	5′-3″ to 7′-8″	9	9	14	14
	7′-9″ to 8′-8″	11	11	17	17
	8′-9″ to 12′-0″	12	12	18	18

Labor Erecting Tin Clad Doors—Continued

Type	Width	Labor Door One Side Mech.	Help.	Doors Two Sides Mech.	Help.
Slide in Pairs	4′-0″ to 4′-5″	9	9	14	14
	4′-6″ to 9′-8″	11	11	16	16
	9′-9″ to 10′-6″	13	13	18	18
	10′-7″ to 12′-0″	15	15	20	20
	Width				
Vertical Sliding	to 4′-10″	13	13	21	21
	4′-11″ to 7′-6″	15	15	24	24
	7′-7″ to 10′-2″	17	17	26	26
	10′-3″ to 12′-0″	19	19	28	28
	Door Height				
Single Swing (Flush or Lap)	to 5′-9″	5	5	7	7
	5′-10″ to 8′-9″	5½	5½	8	8
	8′-10″ to 12′	6	6	9	9
	Door Height				
Swing in Pairs (Flush or Lap)	to 5′-9″	8	8	12	12
	5′-10″ to 8′-9″	9	9	14	14
	8′-10″ to 12′-0″	10	10	16	16



Swinging Type Tin Clad Door



Gravity Sliding Type Tin Clad Door

Cost of One Single Sliding Tin Clad Fire Door For 4′-0″x7′-0″ Wall Opening

The following estimate includes door, track and hangers and necessary hardware but does not include frame.

	Hours	Rate	Total	Rate	Total
1 door, 4′-8″x7′-8″, 36 sq. ft.		$.....	$.....	$ 2.40	$ 86.40
Track, hangers, hardware		.....	.....	80.00	80.00
Mechanic	7	.....	.....	7.00	49.00
Helper	7	.....	.....	5.00	35.00
Cost per opening	14		$.....		$250.40

For doors on both sides of wall, double the above prices.

Cost of One Pair Double Sliding Tin Clad Fire Doors for 6′-0″x7′-0″ Wall Opening

The following estimate includes cost of doors, track, hangers and necessary hardware but does not include frame.

	Hours	Rate	Total	Rate	Total
1 pr. tin clad doors, 52 sq. ft.		$.....	$.....	$ 2.40	$124.80
Track, hangers, hardware		.....	.....	170.00	170.00
Mechanic	11	.....	.....	7.00	77.00
Helper	11	.....	.....	5.00	55.00
Cost per opening.....	22		$.....		$426.80

For doors on both sides of wall, double the above prices.

Cost of One Lap Type Single Swinging Tin Clad Fire Door for 3′-0″x7′-0″ Wall Opening

The following estimate includes cost of door, hardware, automatic controls but does not include frame.

	Hours	Rate	Total	Rate	Total
1 door, 3′-8″x7′-4″, 27 sq. ft.		$.....	$.....	$ 2.40	$ 64.80
Hardware and controls..		.....	.....	84.00	84.00
Mechanic	5	.....	.....	7.00	35.00
Helper	5	.....	.....	5.00	25.00
Cost per opening.....	10		$.....		$208.80

Cost of One Pair Lap Type Double Swinging Tin Clad Fire Doors for 6′-0″x7′-0″ Wall Opening

The following estimate includes cost of doors, hardware, automatic controls but does not include frame.

	Hours	Rate	Total	Rate	Total
1 pr. doors, 49 sq. ft.....		$.....	$.....	$ 2.40	$117.60
Hardware and controls...		.....	.....	166.00	166.00
Mechanic	9	.....	.....	7.00	63.00
Helper	9	.....	.....	5.00	45.00
Cost per opening	18		$.....		$391.60

For doors on both sides of opening, double the above prices.

Cost of One Flush Type Single Swinging Tin Clad Fire Door for 3′-0″x7′-0″ Wall Opening

The following estimate includes cost of door, hardware, and automatic controls, including $3\frac{1}{2}$″x$3\frac{1}{2}$″x$\frac{1}{4}$″ angle iron frame.

	Hours	Rate	Total	Rate	Total
Frame, 19 lin. ft.....		$.....	$.....	$ 2.79	$ 53.01
Labor setting frame.....	3	.....	.....	7.00	21.00
1 door, 3′x7′, 21 sq. ft.....		.....	.....	2.40	50.40
Hardware and controls..		.....	.....	62.00	62.00
Mechanic	5	.....	.....	7.00	35.00
Helper	5	.....	.....	5.00	25.00
Cost per opening.....	13		$.....		$246.41

For doors on both sides of opening, double the above prices.

Cost of One Pair Flush Type Double Swinging Tin Clad Fire Doors for 6'-0"x7'-0" Wall Opening

The following estimate includes cost of doors, hardware and automatic controls, including 4"x5.4" channel iron frame.

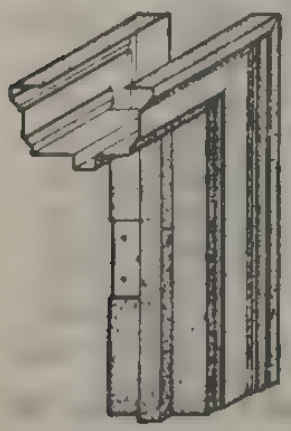
	Hours	Rate	Total	Rate	Total
Frame, 22 lin. ft.		$.....	$.....	$ 3.00	$ 66.00
Labor setting frame	4	.....	.....	7.00	28.00
2 doors, 3'x7', 42 sq. ft.		.....	.....	2.40	100.80
Hardware and controls		.....	.....	145.00	145.00
Mechanic	9	.....	.....	7.00	63.00
Helper	9	.....	.....	5.00	45.00
Cost per opening	22		$.....		$447.80

For doors on both sides of opening, double the above prices. Add cost of painting and overhead and profit to the above prices.

METAL DOOR FRAMES

Combination Bucks, Jambs and Trim

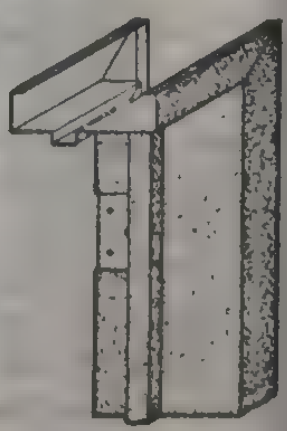
Metal door frames or "combination bucks" combine bucks, jambs and trim. Made of No. 14 or No. 16 gauge cold-rolled steel. Joints between heads and jambs have full continuous weld and are provided with anchors to secure the frames to the walls and have steel angle spreaders welded to the bottom of each side to insure parallel alignment. Steel reinforcements are provided



Type "A"

Type "B"

Type "C"



Type "D"

for hardware cut-outs. Furnished with a shop prime coat of paint.

Prices of Pressed Steel Door Frames

For doors 3'-0"x7'-0" and smaller, rabbeted for 1⅜" or 1¾" doors. Jambs not over 9" wide, 16 ga.

	14 Ga.	16 Ga.
Type "A", full molded trim	$48.00	$43.00
Type "B", quarter round trim	48.00	48.00
Type "C", plain cove trim	43.00	39.00
Type "D", flush type trim	39.00	34.00
For each 6" wider or higher, add	.....	2.25
For labeled frames add	.....	5.60

Set up charge for each order is $25.00.

Economy Type Pressed Steel Door Frames.—Some manufacturers produce pressed steel door frames which are very inexpensive if standard sizes can be used. These frames are usually made from 18 gauge cold rolled steel with a one coat, baked-on primer finish on all sides. Frames are furnished with hinge butts welded on and strike plates applied at the factory. Removable spreaders are fastened at the lower ends of the jambs, to maintain proper alignment during shipping and handling and are easily removed after the frames are set. Anchor clips are welded to each jamb, T-anchors are furnished for installation in masonry walls and each jamb section is provided with a floor anchor plate. Contour of frame section is that of a combination jamb, stop and cove trim on 2 sides.

Standard door frame opening widths are 2′-4″, 2′-6″, 2′-8″, 2′-10″ and 3′-0″, frame opening heights are 6′-8″ and 7′-0″ and all frames are available for 2″, 3″, 4″, or 6″ walls and 1⅜″ or 1¾″ doors.

Price for all standard frames for single doors, $12.50 each; for double doors up to 6′-0″ wide, add $6.00 per frame.

Non-standard frames may be obtained on special order at a cost of $15.00 to $20.00 per frame.

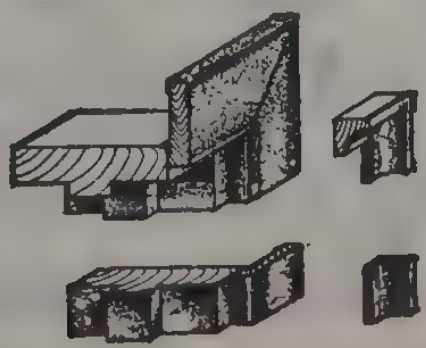
Labor Erecting Pressed Steel Door Frames.—Two carpenters working together should erect 15 to 17 pressed steel door frames per 8-hr. day at the following labor cost per frame:

	Hours	Rate	Total	Rate	Total
Carpenter	1.0	$.....	$.....	$6.75	$6.75
Labor	.2	.....	.....	5.00	1.00
Cost per frame	1.2		$.....		$7.75

Metal Covered Jambs and Trim

Wood jambs and trim covered with No. 24 gauge zinc coated sheet steel, for use with kalamein doors.

Jambs are 1¾″x5½″ rabbeted for 1¾″ doors. Plain casing is ⅞″x3½″. Round edge and brick mold is ⅞″x⅞″.

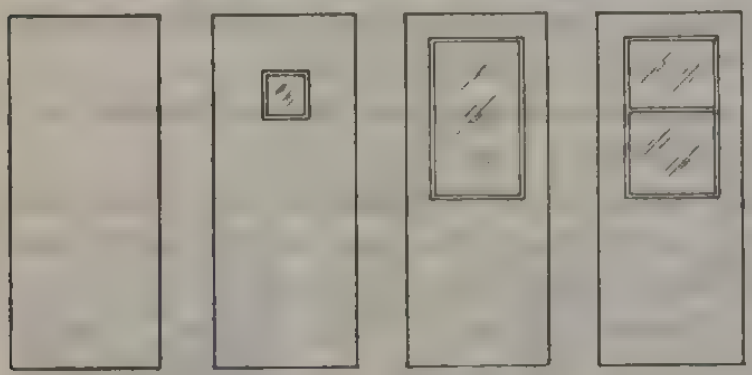


Size Up To	Prices Jamb Width To: 6¾"	8¾"	12"
3'-0"x7'-0"	$40.00	$45.00	$49.00
4'-0"x7'-0"	43.00	48.00	56.00
5'-0"x7'-0"	49.00	52.00	66.00
6'-0"x7'-0"	56.00	59.00	69.00

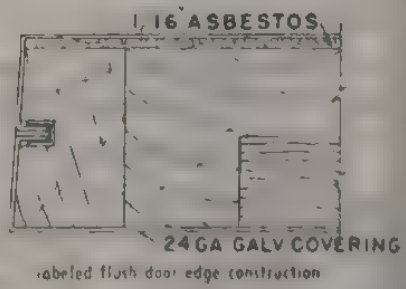
For frames over 7'-0" add $5.00 for each 6" or less.

Kalamein Doors

Kalamein or metal covered doors have kiln-dried spruce or white pine cores. Stiles and rails are mortised and tenoned together and doweled. The cores are covered with 24 gauge zinc coated sheet steel drawn tight and clinched so as to lay smooth. Doors are made to exact size with one edge slightly beveled and are given a shop coat of metallic paint. Where glass openings are provided, the glass is set in hollow molds and held in place with self-tapping sheet metal screws.



Door "A" Door "B" Door "C" Door "D"



Labeled flush door edge construction

Size	Thick	Price per Door Door Types "A"	"B"	"C"	"D"
2'-8"x7'-0"	1¾"	$62.00	$72.00	$77.00	$78.00
3'-0"x7'-0"	1¾"	65.00	75.00	79.00	82.00
3'-4"x7'-0"	1¾"	68.00	79.00	85.00	86.00
3'-8"x7'-0"	1¾"	75.00	86.00	91.00	92.00

For Underwriters' Labeled Doors, Add	Price per Door Door "A"	Door "B"	Door "C"	Door "D"
	$22.00	$23.00	$23.00	$27.00

Doors glazed with ¼" rough wired glass.

Underwriters' labeled doors have 1/16" asbestos panels.

Underwriters' labeled doors cannot have individual lights of glass over 225 sq. in. each.

If non-labeled doors are to be reinforced for hardware, add $12.00 per door.

CHAPTER XXV

STEEL AND ALUMINUM WINDOWS, SCREENS, STORM WINDOWS AND LIGHT INDUSTRIAL DOORS

Steel and aluminum windows and steel doors are available in a great variety of types and sizes to meet almost all building requirements. These products have been standardized by the manufacturers to reduce costs and promote quicker deliveries.

The illustrations included in this Chapter are for reference when selecting requirements. For full description and specifications of available products refer to manufacturers' catalogs.

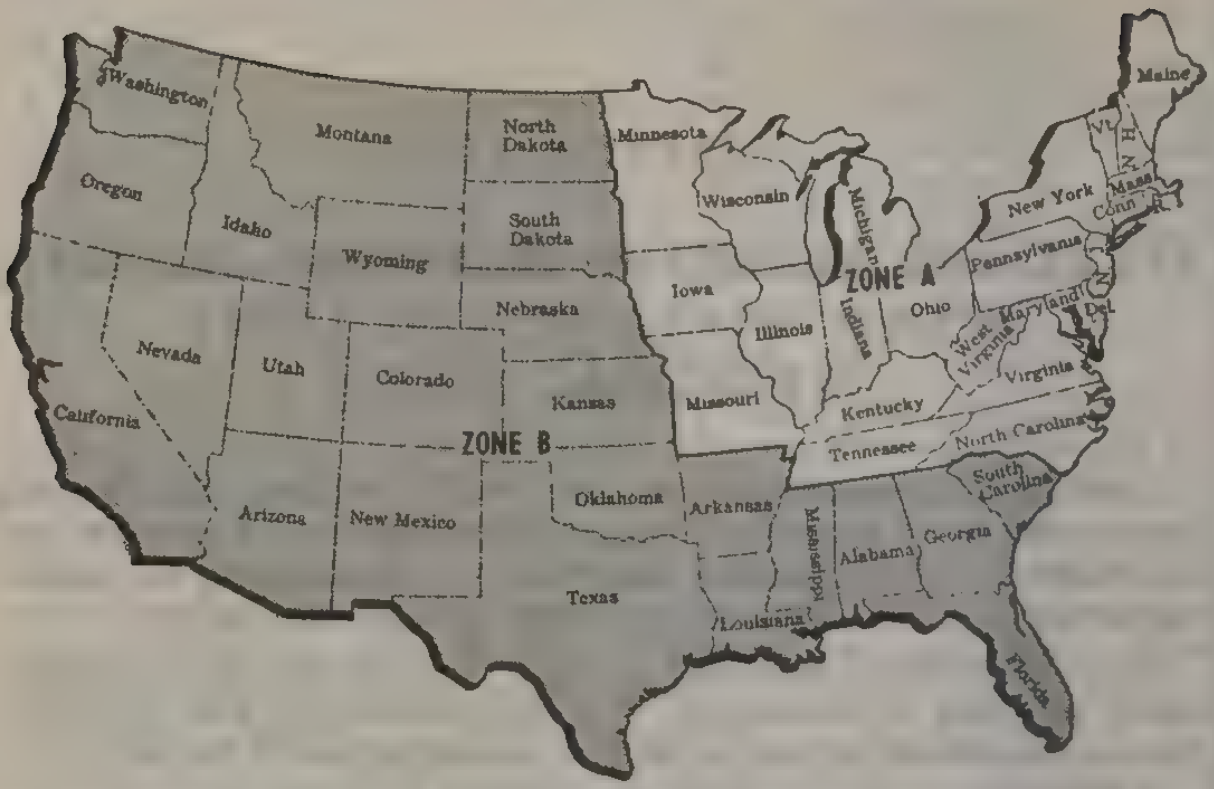
All metal window and door products are either classified as "Standard," "Commodity" or "Special."

"Commodity Units" are those selected from "Standards" which are subject to the greatest demand and are available from manufacturers' warehouse stocks or through dealers engaged in the distribution of these products. "Standard Units" and "Special Units" are not available from stock and must be fabricated and shipped from factory.

The following information will deal with "Commodity Units" only. For "Standard Units" and "Special Units" obtain quotations from manufacturers or their dealer representatives.

Determining Prices of Units.—Prices of steel windows and doors and aluminum windows are determined according to the locality of the job. For this purpose, the country is divided into two zones, as shown on the accompanying map. Prices given on the following pages are for Zone "A". A close approximation of prices for Zone "B" may be obtained by adding 3 to 5 percent to Zone "A" prices for steel units and 2 to 4 percent to Zone "A" prices for aluminum units.

For the seven states west of the continental divide, size data and prices on steel and aluminum residential casements should be obtained from local distributors, as these units produced for the west coast area may sometimes differ from those marketed in the balance of the country.



Note: The marginal cities of Fargo, N. D., Omaha, Nebr., and Kansas City, Kans., are in Zone "A".

Labor Installing Steel Windows and Doors.—Installation costs will vary with the class of labor used, type and size of individual units and job working conditions. However, a reasonably accurate estimate of installation labor costs can be made by multiplying the number of man hours required to install each unit by the prevailing hourly rate of pay for ironworkers, plus rates for pension, welfare, etc., in effect in the area in which job is located.

Product	Window Opening	Man Hours Each Unit
Pivoted, Commercial Projected and Architectural Projected Windows	1. Single Unit*	2.25
	2. Two or more Units*	
	(a) Precast Sills	1.25
	(b) Poured Sills	1.50
Fixed Industrial	1. Single Unit	1.75
	2. Two or More Units	
	(a) Precast Sills	.75
	(b) Poured Sills	1.00
Fixed Architectural	1. Single Unit	2.00
	2. Two or More Units	
	(a) Precast Sills	1.00
	(b) Poured Sills	1.25

*Single ventilator units. For each additional ventilator, ADD ..... .25

Labor Installing Steel Windows and Doors.—Continued

Product	Window Opening	Man Hours Each Unit
Intermediate Windows (Casement, Combination and Projected)	1. In Wood	
	(a) Single Unit	2.75
	(b) Two or More Units	2.25
	2. In Stone	
	(a) Single Unit	3.00
	(b) Two or More Units	2.50
	3. In Masonry	
	(a) Single Unit	2.25
	(b) Two or More Units	1.25
Mullions Only		.50
Mullions with Covers		.75
Residence Casements (Roto)	1. Single Unit	
	(a) In Wood	1.75
	(b) In Masonry or Brick Veneer	1.25
	2. Two or More Units	
	(a) In Wood	1.50
	(b) In Masonry or Brick Veneer	1.00
Residence Casements (Fixed)	1. Single Unit	
	(a) In Wood	1.50
	(b) In Masonry or Brick Veneer	1.00
	2. Two or More Units	
	(a) In Wood	1.25
	(b) In Masonry or Brick Veneer	.75
Casements in Casings	Single or Multiple Units	1.50
Continuous Top Hung, Fixed	Per Lineal Foot	.50
Continuous Top Hung, Swing	Per Lineal Foot	.75
Mechanical Operators, Rack and Pinion	Per Lineal Foot	.75
Mechanical Operators, Lever Arm	Per Lineal Foot	.50
Mechanical Operators, Tension	Per Lineal Foot	1.50

Labor Installing Steel Windows and Doors.—Continued

Product	Window Opening	Man Hours Each Unit
Industrial Doors and Frames	1. Up to 35 Sq. Ft. Per Sq. Ft.	.125
	2. Over 35 Sq. Ft. Per Sq. Ft.	.10
Double Hung Windows	1. Single Units	1.50
	2. Two or More Units	1.25

Screen Installation

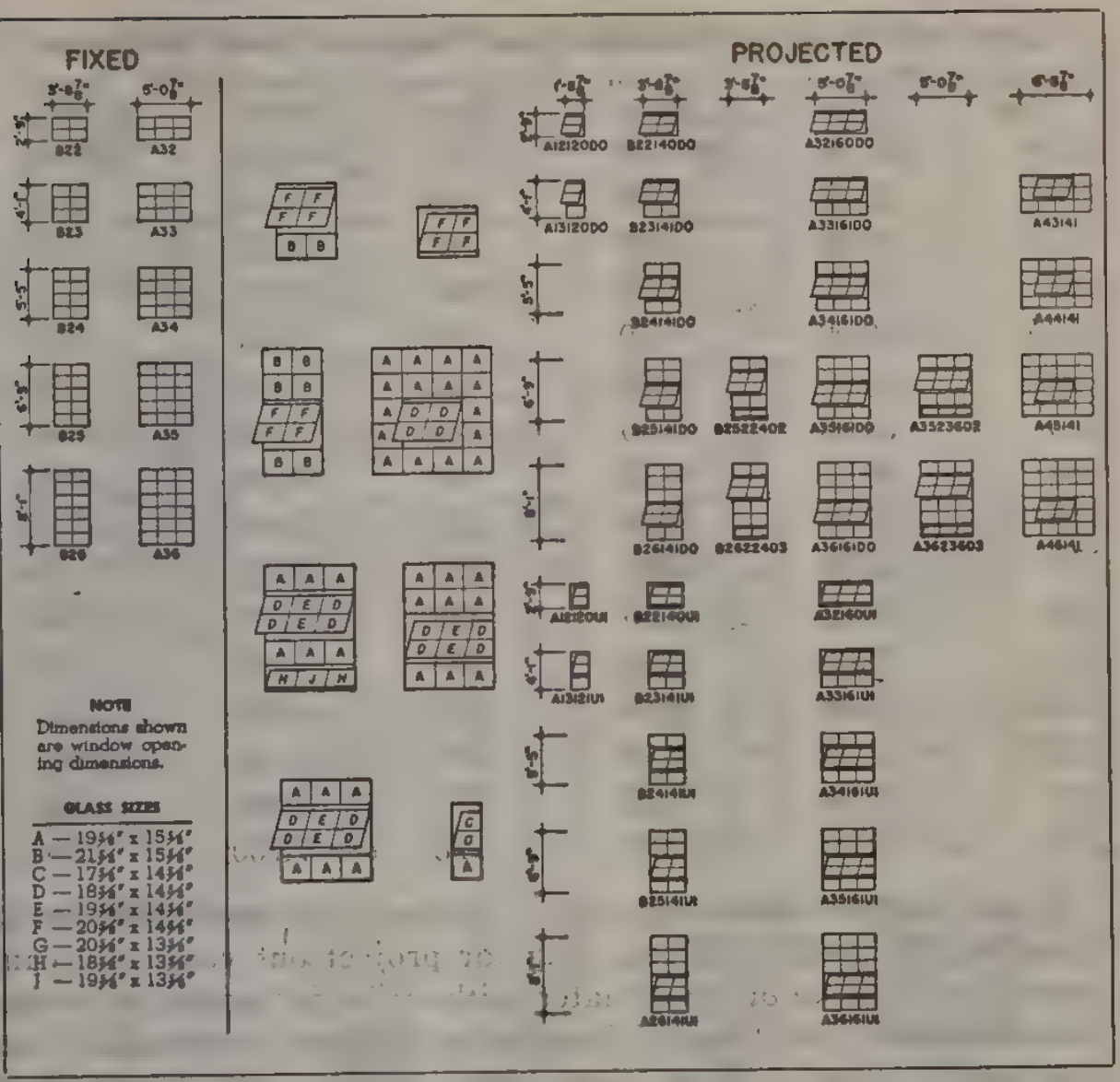
For Projected Windows	Net per Screen	$1.10
For Basement and Utility Windows	Net per Screen	.75
For Security Windows	Net per Screen	1.10
For Casement Windows	Net per Screen	.75
For Pivoted Windows	Net per Vent	1.50

Zone "A" Prices of Commercial Projected Steel Windows

VENTILATED				FIXED	
Window Type	Window Price	Wicket Screen Price	Fixed Screen Price	Window Type	Window Price
*A12120	$22.00	$ 7.40	$ 5.50	B-22	$12.00
*A13121	23.50	7.40	5.50	B-23	15.00
*B22140	28.00	10.20	8.30	B-24	17.00
*B23141	31.00	10.20	8.30	B-25	21.00
*B24141	35.00	10.20	8.30	B-26	28.00
*B25141	39.50	10.20	8.30	A-32	22.00
B2522402	53.00	†16.20	....	A-33	20.00
*B26141	42.00	10.20	8.30	A-34	21.00
B2622403	56.00	†16.20	....	A-35	25.00
*A32160	32.50	12.60	10.30	A-36	32.00
*A33161	38.00	12.60	10.30	A-42	18.00
*A34161	42.00	12.60	10.30	A-43	36.00
*A35161	47.00	12.60	10.30	A-44	32.00
*A36161	51.00	12.60	10.30	A-45	37.00
A3523602	64.00	†19.70			
A3623603	69.00	†19.70			
A43141	42.00	9.80	....		
A44141	46.00	9.80	....		
A45141	52.00	9.80	....		
A46141	58.00	9.80	....		

*These types available with either project-out or project-in vents.

†Price includes wicket screen for project-out vent and fixed screen for project-in vent.


FIXED
PROJECTED
NOTE
Dimensions shown are window opening dimensions.
GLASS SIZES
A — 19¾" x 15¾"
B — 21¾" x 15¾"
C — 17¾" x 14¾"
D — 18¾" x 14¾"
E — 19¾" x 14¾"
F — 20¾" x 14¾"
G — 20¾" x 13¾"
H — 18¾" x 13¾"
J — 19¾" x 13¾"

Types and Sizes Commercial Projected Windows

Prices include cam handle and pole ring for project out ventilators and cam handle with strike or spring latch with strike for project in ventilators. Hardware is cadmium plated.

Prices also include standard installation fittings, provisions for standard screens, bonderizing and one factory coat of paint. Glass, putty, glazing and glazing clips not included.

Zone "A" Prices of Mullions and Covers

Lights High	2	3	4	5	6
Mullions	$1.70	$2.20	$2.80	$3.30	$7.80
Covers	1.40	2.10	2.70	3.30	3.90

Zone "A" Prices of Architectural Projected Steel Windows

Window Type	Window Price	Screen Price	Window Type	Window Price	Screen Price
252A	$27.00	$ 7.80	215	$52.00	$15.60
252B	27.50	5.90	216	55.00	15.60
253	32.00	7.80	218	57.00	15.60
261	26.00	5.10	221	30.00	6.30
262A	29.00	8.70	222A	34.00	10.70
262B	29.50	6.80	222B	34.50	8.80
263	34.00	8.70	223	37.00	10.70
264	39.00	8.70	224	41.00	10.70
265	52.00	13.80	225	56.00	17.00
266	56.00	13.80	226	59.00	17.00
268	58.00	13.80	228	62.00	17.00
211	27.00	5.80	273	39.00	12.10
212A	33.00	9.80	274	46.00	12.10
212B	33.50	7.90	275	65.00	18.90
213	36.00	9.80	276	70.00	18.90
214	39.00	9.80	278	78.00	18.90

Prices include bronze operating hardware for ventilated units. Cam handle, strike and pole ring for project out vents and cam handle with strike or spring latch with strike for project in vents. Also included are standard installation fittings, bonderizing and one factory coat of paint. Glass, putty, glazing and glazing clips not included.

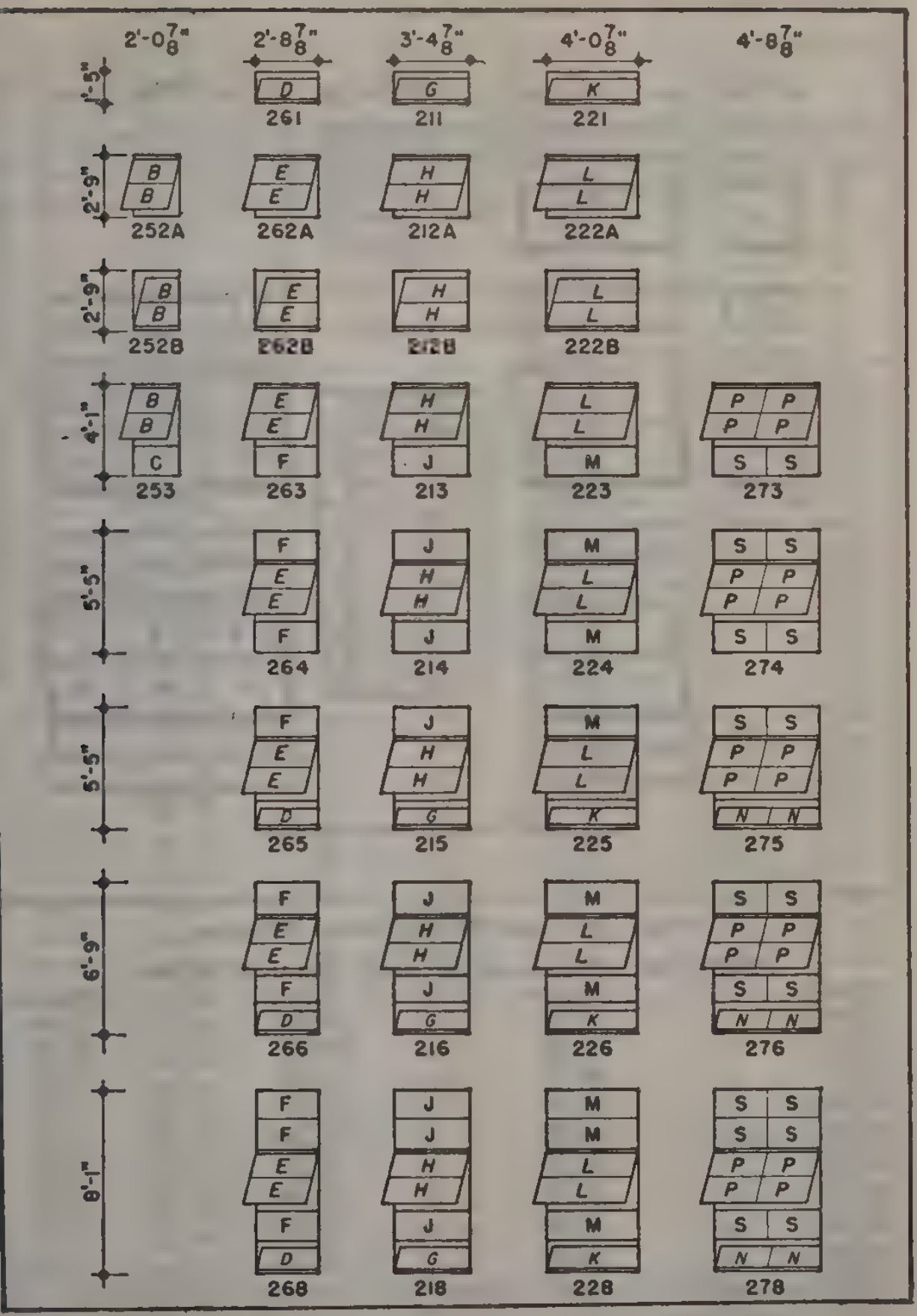
Screen prices include screens for all vents in unit. Wicket screens are furnished for project out vents and outside fixed screens for project in vents. Prices also include clips for attachment.

Zone "A" Prices of Extras

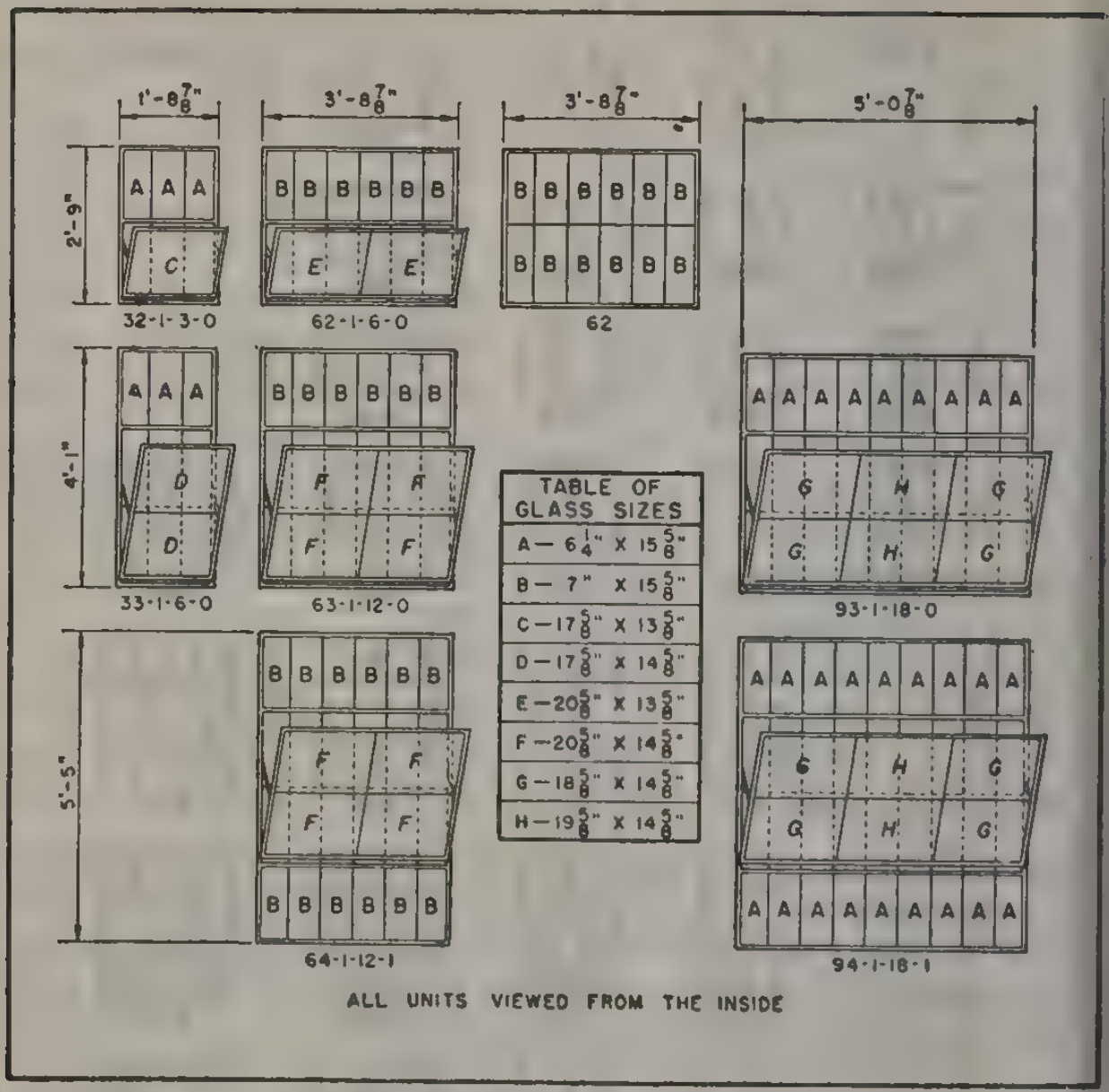
Polished bronze hardware in place of standard bronze hardware, add per vent.....$1.20

Zone "A" Prices of Mullions and Covers

Lights High	1	2	3	4	5	6
Mullions	$1.50	$2.10	$2.70	$3.50	$4.10	$4.70
Covers	1.30	2.10	2.80	3.30	4.10	4.70



Types and Sizes of Architectural Projected Steel Windows



Types and Sizes Security Steel Windows

Zone "A" Prices of Security Steel Windows

Window Type	Window Price	Screen Price	Mullion Price
32130	$31.90	$ 6.20	$1.60
33160	40.00	8.50	2.10
62 Fixed	16.00	....	1.60
62160	43.00	8.50	1.60
631120	54.00	11.80	2.10
641121	59.00	11.80	2.60
931180	66.00	14.00	2.10
941181	74.00	14.00	2.60

Prices include standard operating hardware, installation, fittings, bonderizing and one factory coat of paint. Glass, putty, glazing and glazing clips are not included.

Anchors

Anchors for securing frames to wood or masonry walls are included with window units.

Four anchors per opening are furnished for heights up to and including 4′-5½″. Six anchors per opening to and including 5′-9½″. Eight anchors per opening to and including 8′-1½″.

Zone "A" Prices of Residential Steel Casements

Ventilated Casements

Window Type	Window Price	Head and Jamb Fins Per Set	Inside Casing Price	In/Out Trim Price	Screen Price	Storm Window Price
1212	$15.40	$2.10	$ 5.70	$ 8.60	$2.00	$ 9.40
1313	16.80	2.50	6.90	9.90	2.65	10.20
1413	19.40	3.10	7.80	11.30	2.65	11.60
1414	19.40	3.10	7.80	11.30	3.15	11.60
1514	21.20	3.50	8.70	13.10	3.15	13.00
2212	19.30	2.30	6.90	10.60	2.00	18.80
2313	22.20	2.70	8.10	12.00	2.65	20.40
2414	25.10	3.30	9.00	13.40	3.15	23.20
2413	25.10	3.30	9.00	13.40	2.65	23.20
2514	28.00	3.70	9.90	15.20	3.15	26.00
2222	28.90	2.30	6.90	10.60	4.00	18.80
2323	34.00	2.70	8.10	12.00	5.30	20.40
2424	36.10	3.30	9.00	13.40	6.30	23.20
2423	36.10	3.30	9.00	13.40	5.30	23.20
2524	39.40	3.70	9.90	15.20	6.30	26.00
3222	28.90	2.70	8.10	12.90	4.00	28.20
3323	36.80	3.10	9.40	14.30	5.30	30.60
3424	42.00	3.70	10.20	15.70	6.30	34.80
3423	42.00	3.70	10.20	15.70	5.30	34.80
3524	46.20	4.10	11.10	17.50	6.30	39.00
4222	35.40	3.00	9.20	14.90	4.00	30.80
4323	40.50	3.40	10.50	16.30	5.30	34.60
4424	44.80	4.00	11.30	17.70	6.30	39.60
4423	44.80	4.00	11.30	17.70	5.30	39.60
4524	50.40	4.40	12.10	19.50	6.30	45.80
5222	37.90	3.50	10.30	16.90	4.00	33.40
5323	43.00	3.90	11.60	18.30	5.30	39.40
5424	49.40	4.50	12.40	19.70	6.30	47.00
5423	49.40	4.50	12.40	19.70	5.30	47.00
5524	56.00	4.90	13.20	21.50	6.30	56.80

Fixed Casements

Window Type	Window Price	Storm Window Price	Window Type	Window Price	Storm Window Price
12	$3.80	$ 9.40	34	$10.20	$36.60
13	4.60	10.20	35	11.60	27.00
14	5.60	11.60	42	9.30	....
15	6.40	13.00	43	10.90	....
22	5.70	12.80	44	12.50	....
23	6.70	15.00	45	14.20	....
24	7.90	18.80	52	11.00	....
25	8.90	21.40	53	13.00	....
32	7.40	15.60	54	15.00	....
33	8.80	20.00	55	16.80	....

Prices of ventilated units include locking handles, Roto underscreen operators (lever underscreen operators also available at reduced price) and standard installation fittings, bonderizing and one factory coat of paint for both ventilated and fixed units. Glass, putty, glazing, glazing clips and mastic not included.

Screen prices include screens for all vents in unit and clips for attachment. Storm windows are factory glazed and prices include clips for attachment.

Zone "A" Prices of Extras

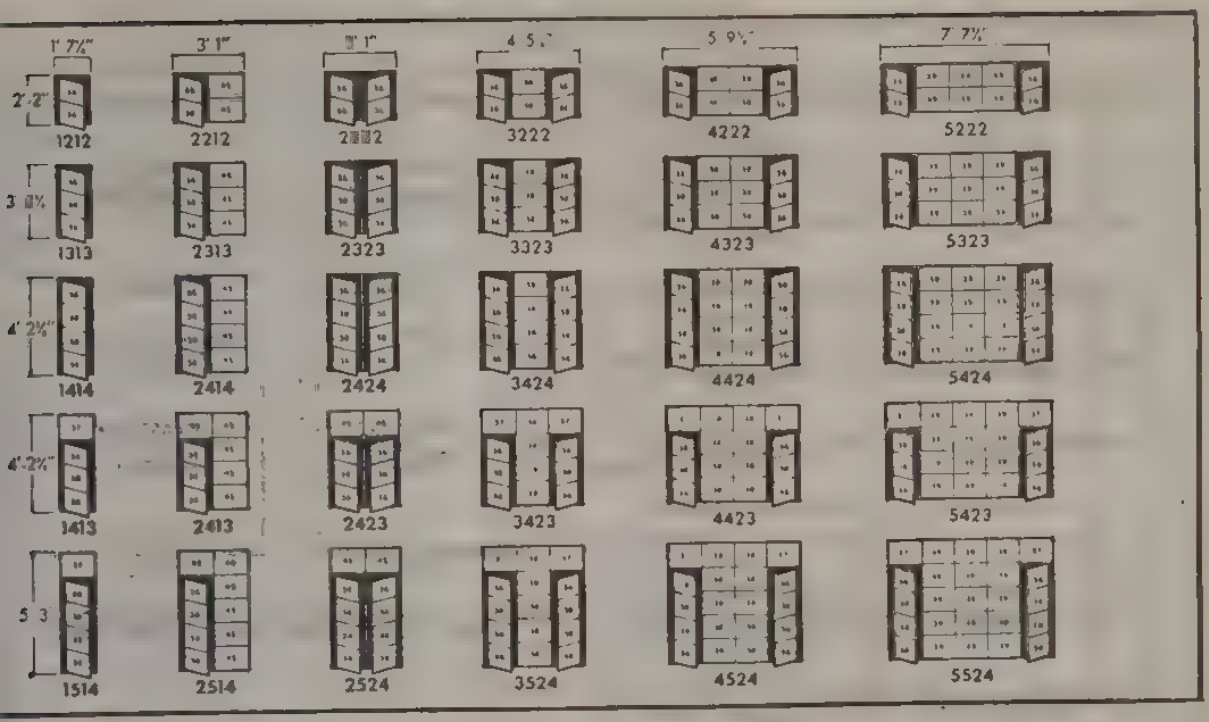
Bronze hardware for roto casements in lieu of bronze lacquer finish hardware, add per side hinged vent.....$ 4.00

Mastic, use 1 quart for each 40 lin. ft. of application

Per quart (4 lbs.)	2.70
Per gallon (16½ lbs.)	9.30
5 gallons (85 lbs.)	43.30

Zone "A" Prices of Mullions

Vertical Mullions		Horizontal Mullions		Pipe Corners	
2-Lt	$0.90	1-Lt	$1.50	2-Lt	$4.80
3-Lt	1.30	2-Lt	2.40	3-Lt	6.10
4-Lt	1.60	3-Lt	3.40	4-Lt	7.50
5-Lt	2.10	4-Lt	4.10	5-Lt	8.90
		5-Lt	5.30		



Types and Sizes of Residence Steel Casements

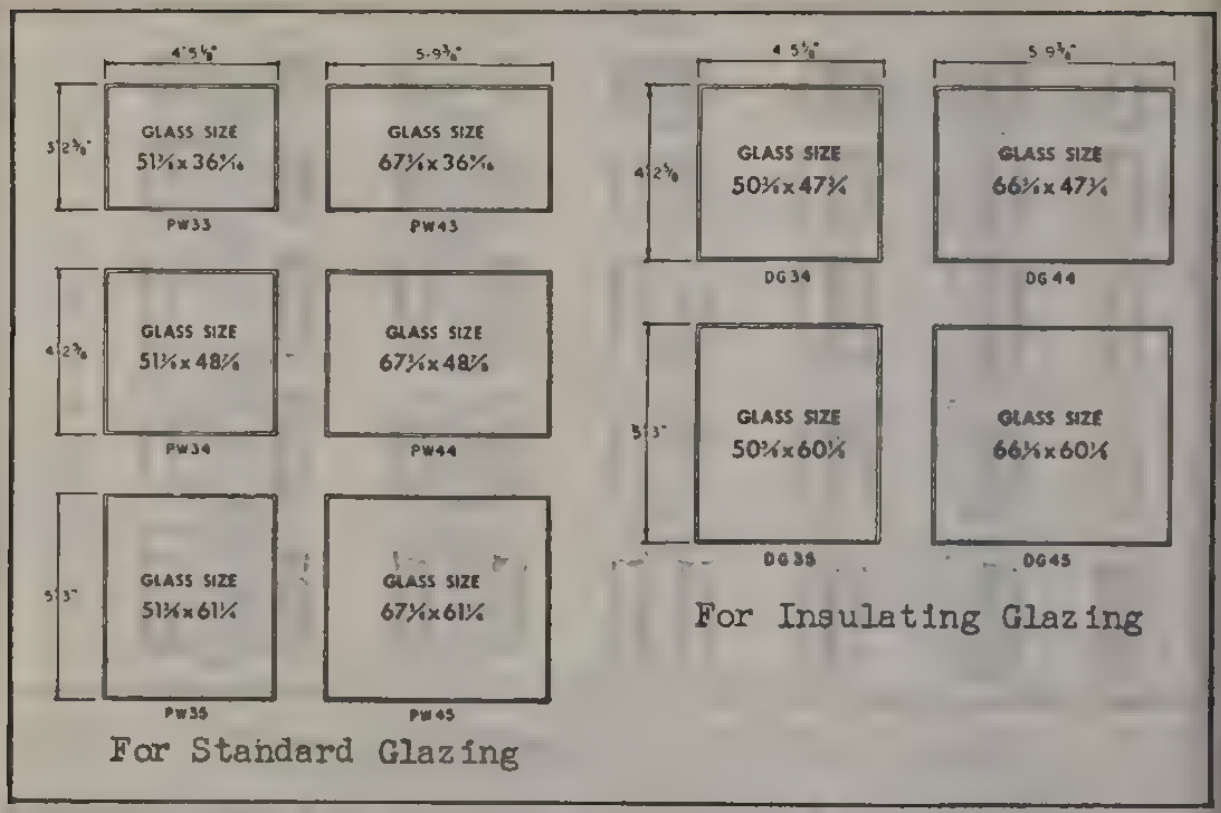
Zone "A" Prices of Residential Steel Casement Picture Windows

For Standard Glazing		For Insulating Glazing	
Window Type	Window Price	Window Type	Window Price
PW33	$6.70	DG34	$26.70
PW34	7.70	DG35	28.80
PW35	8.50	DG44	28.80
PW43	7.70	DG45	31.00
PW44	8.50		
PW45	9.30		

Prices are for four sided frames, shipped assembled, with two standard vertical mullions attached. Units for insulating glazing have glazing strips attached. Units are bonderized and painted one prime coat of oven-baked paint. Glass, putty and glazing are not included.

Zone "A" Prices of Steel Ranch Windows

Window Type	Window Price	Screen Price	Window Type	Window Price	Screen Price
R11	$ 4.50	$ ...	R21210	$32.60	$16.00
R11110	16.30	8.00	R22211	36.50	16.00
R12	6.80	...	R23212	40.60	16.00
R12111	18.00	8.00	R32211	45.50	16.00
R13	8.60	...	R33212	50.60	16.00
R13112	20.40	8.00			



Picture Window Units for Use with Residential Steel Casements

Prices include solid bronze cam handles for ventilators. Windows are bonderized and painted one coat of oven-baked paint. May be glazed with stock size lights of ½" insulating glass. Glass, putty, glazing and glazing clips are not included.

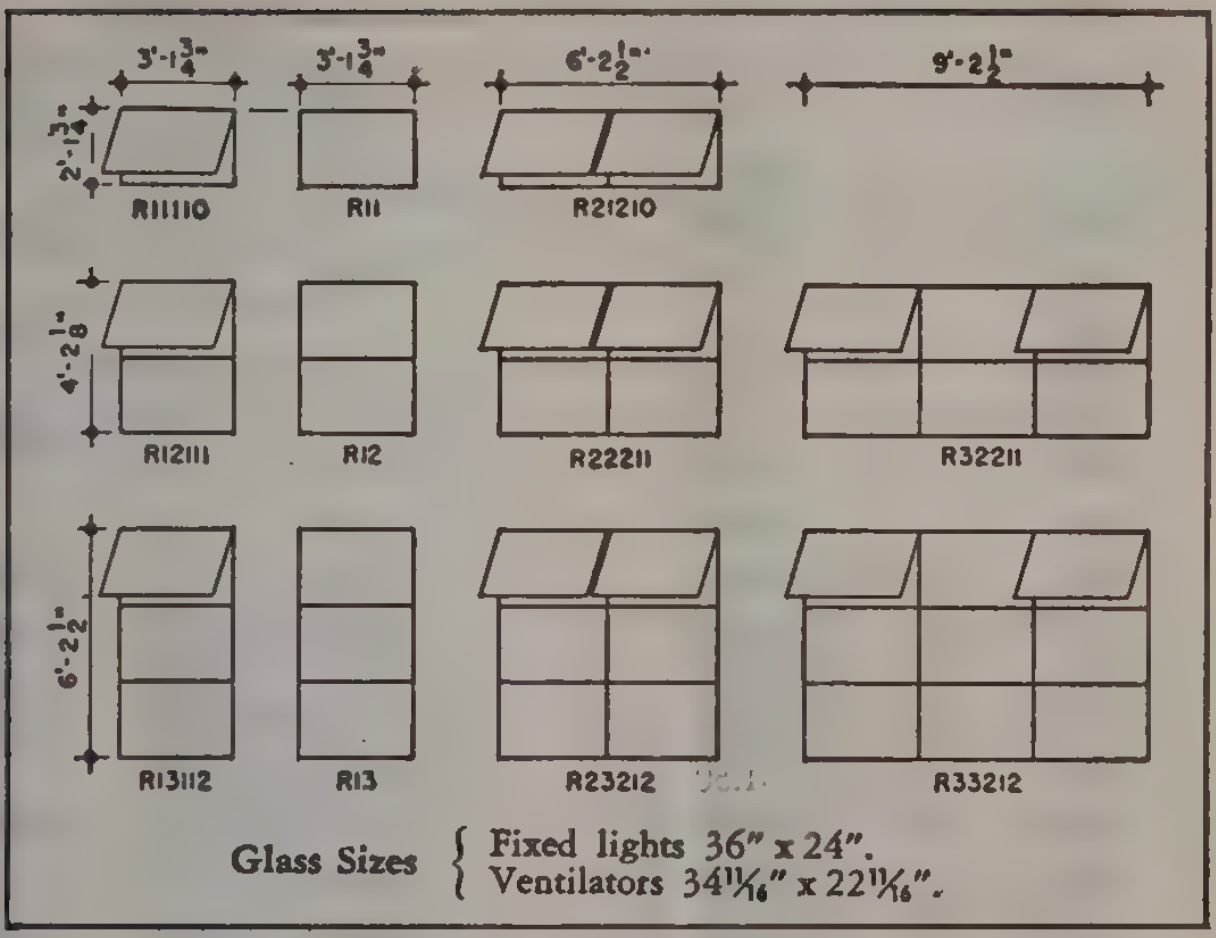
Screen prices include wicket type screens, with bronze screen cloth, for all vents in unit and clips for attachment.

Zone "A" Prices of Mullions and Fins

	Horizontal Widths			Vertical Heights		
	3'-1¾"	6'-2½"	9'-2½"	2'-1¾"	4'-2⅛"	6'-2½"
Mullions	$...	$...	$...	$1.00	$1.50	$2.00
Fins	1.10	1.50	2.50	.80	1.20	1.50

Zone "A" Prices of Basement and Utility Steel Windows

Window prices include steel latch with ring and keeper, bonderizing and one factory coat of paint. Glass, putty, glazing and glazing clips not included.



Steel Ranch Windows

Screen and storm window prices include clips for attachment. Storm panels are factory glazed.

Basement Windows

Window Type	Opening Dimensions	Window Price	Mullion Price	Screen Price	Storm Sash Price
2-Lt.	2'-8½"x1'- 2⅝"	$ 9.00	$1.30	$2.30	$5.20
2-Lt.	2'-8½"x1'- 6⅝"	11.00	1.30	2.60	5.90
2-Lt.	2'-8½"x1'-10⅝"	13.00	1.30	2.90	6.40

Utility Windows

Window Type	Opening Dim. Width	Opening Dim. Height	Window List Price	Mullion List Price	Screen List Price
22121	2'-8½"	3'-6⅝"	$8.10	$1.90	$2.90

Zone "A" Prices of Intermediate Projected Steel Windows

Window Type	Window Price	Wicket Screen Price	Fixed Screen Price
452A	$27.00	$ 7.80	$ ...
452B	27.50	....	5.90
453	30.10	7.80	...
461	26.00	....	5.10
462A	29.00	8.70	...
462B	29.50	....	6.80
463	34.00	8.70	...
464	39.00	8.70	...
465	52.00	8.70	5.10
466	58.00	8.70	5.10
468	63.00	8.70	5.10
411	26.50	....	5.80
412A	31.50	9.80	...
412B	32.50	....	7.90
413	35.00	9.80	...
414	37.00	9.80	...
415	56.00	9.80	5.80
416	58.50	9.80	5.80
418	64.00	9.80	5.80
421	29.50	....	6.30
422A	33.50	10.70	...
422B	34.00	....	8.80
423	36.00	10.70	...
424	39.00	10.70	...
425	54.70	10.70	6.30
426	60.00	10.70	6.30
428	66.00	10.70	6.30
473	42.10	12.10	...
474	49.00	12.10	...
475	63.00	12.10	6.80
476	65.60	12.10	6.80
478	72.20	12.10	6.80

Window prices include unpolished bronze operating hardware for ventilated units, cam handle, strike and pole ring for project out vents and cam handle with strike or spring latch with strike for project in vents.

Prices also include standard installation fittings, bonderizing and one factory coat of paint. Glass, putty, glazing and glazing clips not included.

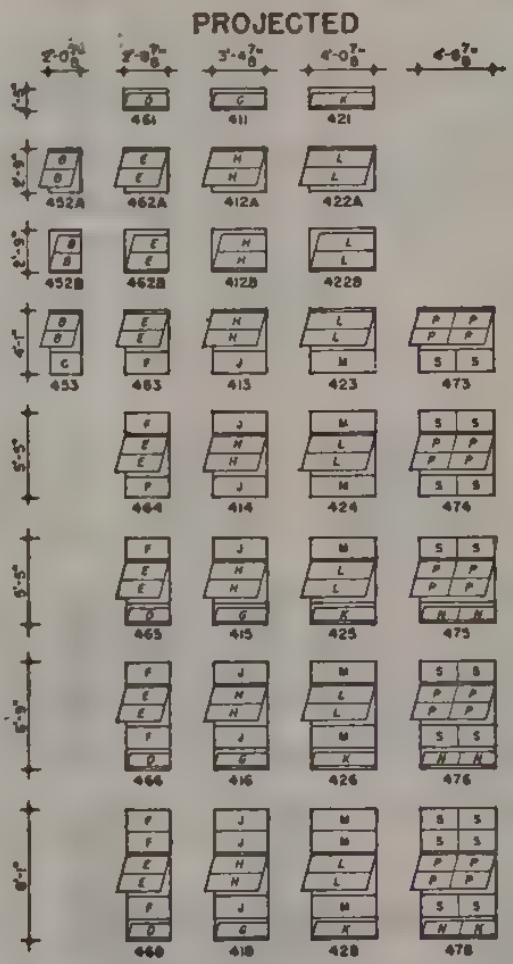
Screen prices include screens for all vents in unit. Wicket screens are furnished for project out vents. Project in vents have fixed outside screens. Clips for attachment are also included.

NOTES

- Dimensions shown are window opening dimensions.
- Windows are shown as viewed from the outside.
- **Warehouse Types** include only units with ventilator swing exactly as shown, and equipped with hardware consisting of cam acting locking handles for open-out vents and either cam acting locking handles or spring latches for open-in vents. These units are prepared for interior wicket screens on open-out vents, and exterior fixed screens on open-in vents.

SCHEDULE OF GLASS SIZES

Mark	Glass Size
B	21⅝" x 14⅝"
C	23¼" x 15⅝"
D	29⅝" x 13⅝"
E	29⅝" x 14⅝"
F	31¼" x 15⅝"
G	37⅝" x 13⅝"
H	37⅝" x 14⅝"
J	39¼" x 15⅝"
K	45⅝" x 13⅝"
L	45⅝" x 14⅝"
M	47¼" x 15⅝"
N	26⅝" x 13⅝"
P	26⅝" x 14⅝"
S	27⅛" x 15⅝"



Types and Sizes Intermediate Projected Windows

Zone "A" Prices of Mullions

Lights High	1	2	3	4	5	6
Price	$2.80	$4.20	$5.50	$6.80	$8.20	$9.40

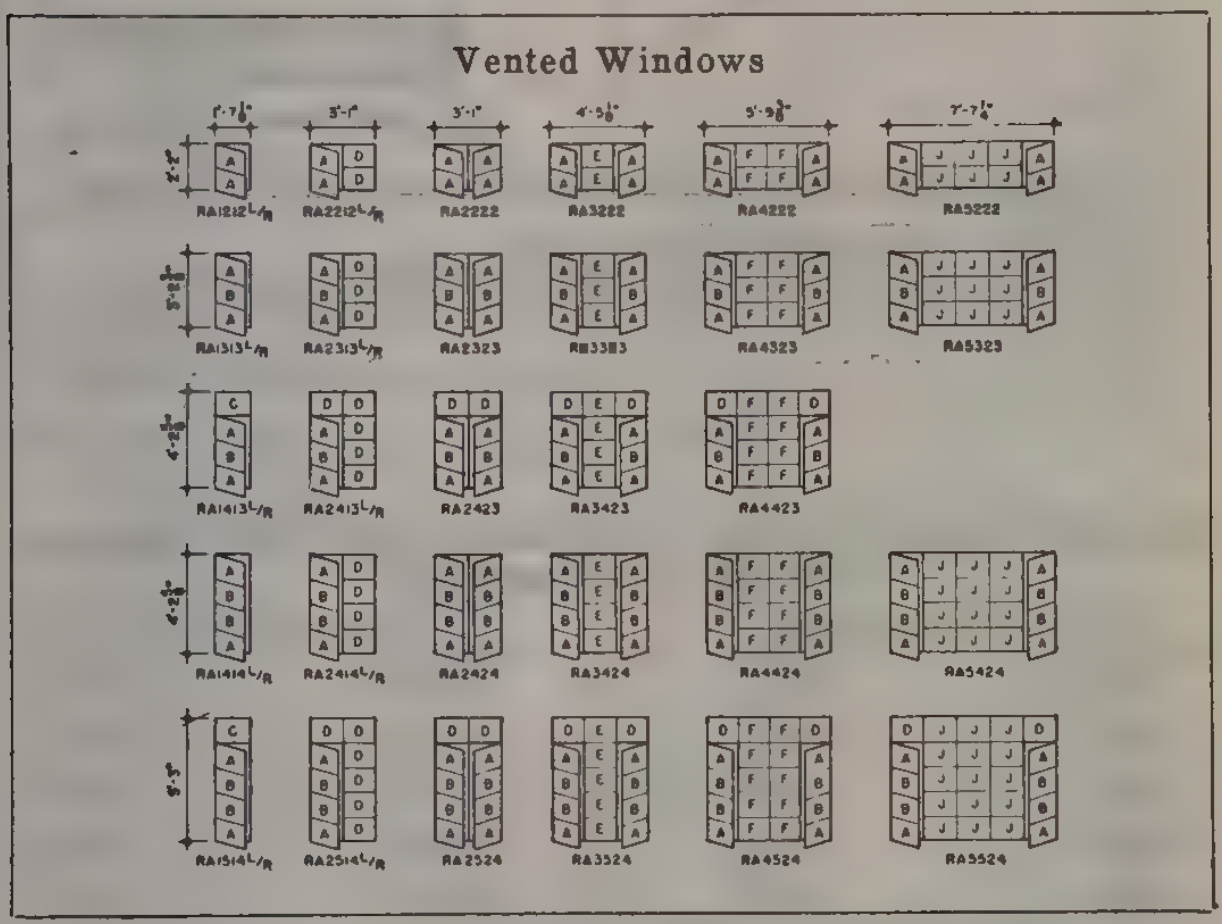
Zone "A" Prices of Aluminum Residential Casements

VENTILATED				FIXED	
Window Type	Window Price	Screen Price	Storm Sash Price	Window Type	Window Price
1212	$19.40	$2.40	$13.00	12	$ 7.70
1313	21.00	2.90	14.20	13	8.80
1413	22.20	2.90	15.00	14	10.00
1414	22.50	3.50	15.00	..	....
1514	24.10	3.50	18.20	15	11.10
2212	21.00	2.40	26.00	22	9.50
2313	24.00	2.90	28.40	23	11.00
2413	26.50	2.90	32.40	24	12.60
2414	26.60	3.50	32.40	..	....
2514	29.20	3.50	36.40	25	14.20
2222	30.50	4.80	25.40	..	....
2323	33.50	5.80	28.40	..	....
2423	35.80	5.80	32.20	..	....
2424	36.10	7.00	32.20	..	....
2524	39.00	7.00	36.40	..	....
				32	11.10
				33	13.30
				34	15.00
				..	....
				35	18.00
3222	35.00	4.80	39.40	..	....
3323	36.70	5.80	42.60	..	....
3423	39.30	5.80	47.80	..	....
3424	39.80	7.00	47.80	..	....
3524	43.50	7.00	54.60	..	....
4222	35.90	4.80	52.80	42	13.90
4323	42.00	5.80	47.60	43	16.20
4423	46.00	5.80	47.60	44	18.60
4424	47.00	7.00	55.00	..	....
4524	53.00	7.00	63.80	45	21.00
5222	42.70	4.80	46.20	52	15.90
5323	46.40	5.80	54.00	53	18.80
5424	50.20	7.00	65.80	54	21.50
5524	54.90	7.00	78.40	55	24.30

Prices include aluminum die cast roto operator with aluminum arm. Operator case and crank are brushed to a satin finish and given one coat of clear Duranite phenolic resin baked-on plastic coating. Casements are etched in a hot acid bath and receive a dip coat of methacrylate lacquer. Also included are wood screws and sill anchors when specified. Glass, putty, glazing, glazing clips and mastic are not included.

Screen prices include screens for all vents in unit. Screens have aluminum frames and 18x14 mesh aluminum cloth.

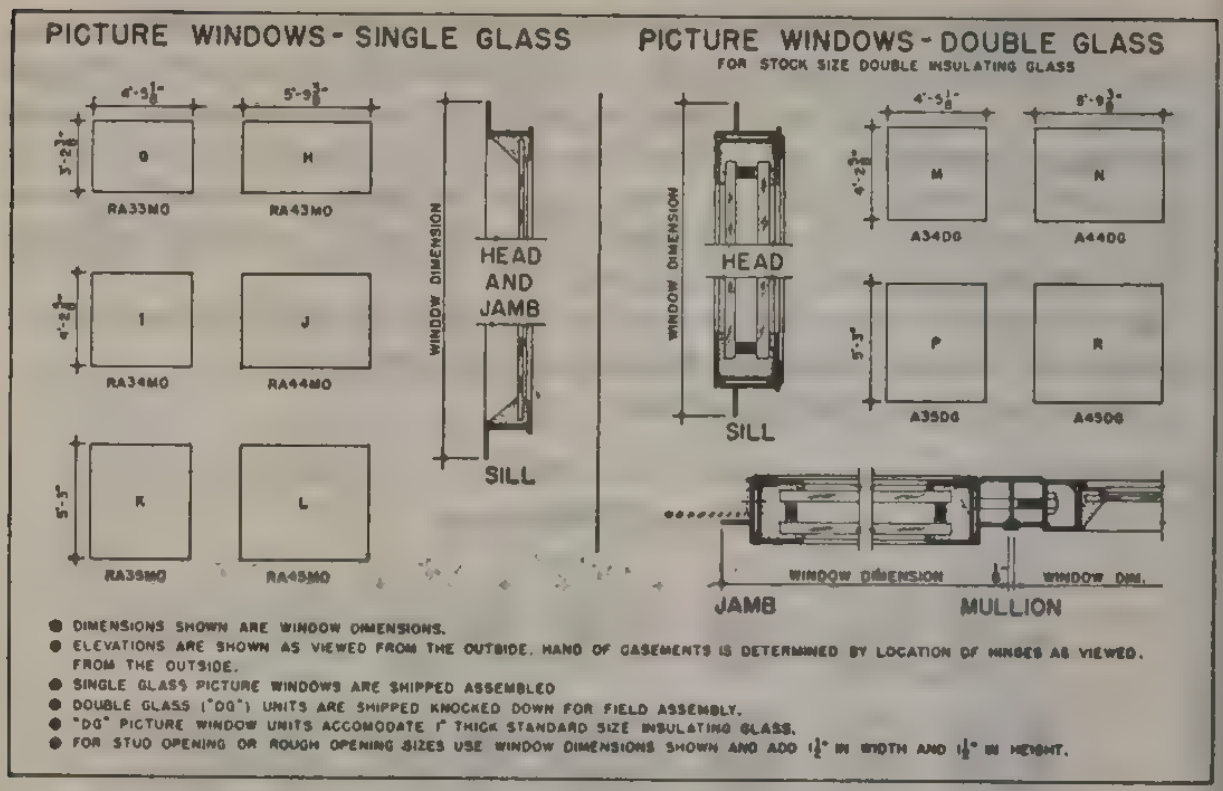
Storm sash are factory glazed.



Aluminum Residential Casements

Zone "A" Prices of Mullions and Fins

Lts. Wide or High	Vertical Mullions	Head Fins Each Head	Jamb Fins Each Jamb
1	$ . . .	$0.70	$ . . .
2	1.10	.90	.70
3	1.70	1.30	.90
4	2.20	1.60	1.20
5	2.80	2.10	1.40


PICTURE WINDOWS - SINGLE GLASS
PICTURE WINDOWS - DOUBLE GLASS
FOR STOCK SIZE DOUBLE INSULATING GLASS
RA33MO
RA43MO
RA34MO
RA44MO
RA35MO
RA45MO
HEAD AND JAMB
SILL
WINDOW DIMENSION
HEAD
SILL
A34DG
A44DG
A35DG
A45DG
JAMB
MULLION
WINDOW DIMENSION
WINDOW DIM.
● DIMENSIONS SHOWN ARE WINDOW DIMENSIONS.
● ELEVATIONS ARE SHOWN AS VIEWED FROM THE OUTSIDE. HAND OF CASEMENTS IS DETERMINED BY LOCATION OF HINGES AS VIEWED FROM THE OUTSIDE.
● SINGLE GLASS PICTURE WINDOWS ARE SHIPPED ASSEMBLED
● DOUBLE GLASS ("DG") UNITS ARE SHIPPED KNOCKED DOWN FOR FIELD ASSEMBLY.
● "DG" PICTURE WINDOW UNITS ACCOMODATE 1" THICK STANDARD SIZE INSULATING GLASS.
● FOR STUD OPENING OR ROUGH OPENING SIZES USE WINDOW DIMENSIONS SHOWN AND ADD 1/2" IN WIDTH AND 1/2" IN HEIGHT.

Picture Window Units for Use with Aluminum Residential Casements

Zone "A" Prices of Picture Windows for Use with Aluminum Residential Casements

For Standard Glazing		For Insulating Glazing	
Window Type	Window Price	Window Type	Window Price
33MO	$10.00	34DG	$28.00
34MO	10.70	35DG	31.00
35MO	11.40	44DG	30.00
43MO	11.50	45DG	33.00
44MO	11.70		
45MO	12.40		

Prices are for four sided frames units for standard glazing are shipped assembled units for insulating glazing are shipped knocked down, with glazing stops included. Glass, putty and glazing are not included.

Zone "A" Prices of Aluminum Awning Windows

Window Type	Window Price	Screen Price	Storm Sash Price
#12	$33.00	$ 4.20	$20.00
#13	37.80	4.80	24.50
#14	43.00	5.60	30.10
#15	49.00	7.20	32.60
#22	40.00	5.80	26.80
#23	43.60	7.20	34.30
#24	48.00	8.50	41.00
#25	53.60	10.50	56.10
#32	44.50	7.10	35.00
#33	47.40	8.80	52.00
#34	56.00	11.30	61.80
#35	60.00	15.40	77.80

Prices include a mechanical operator with crank handle. Windows are glazed by using snap-in aluminum beads. Prices include integral fin, and glazing.

Windows are weatherstripped and receive a dip coat of methacrylate lacquer.

Screen prices include screens for all vents in unit. Screens have aluminum frames and 18x14 mesh aluminum cloth.

Storm sash are factory glazed.

Zone "A" Prices of Picture Windows for Use with Aluminum Awning Windows

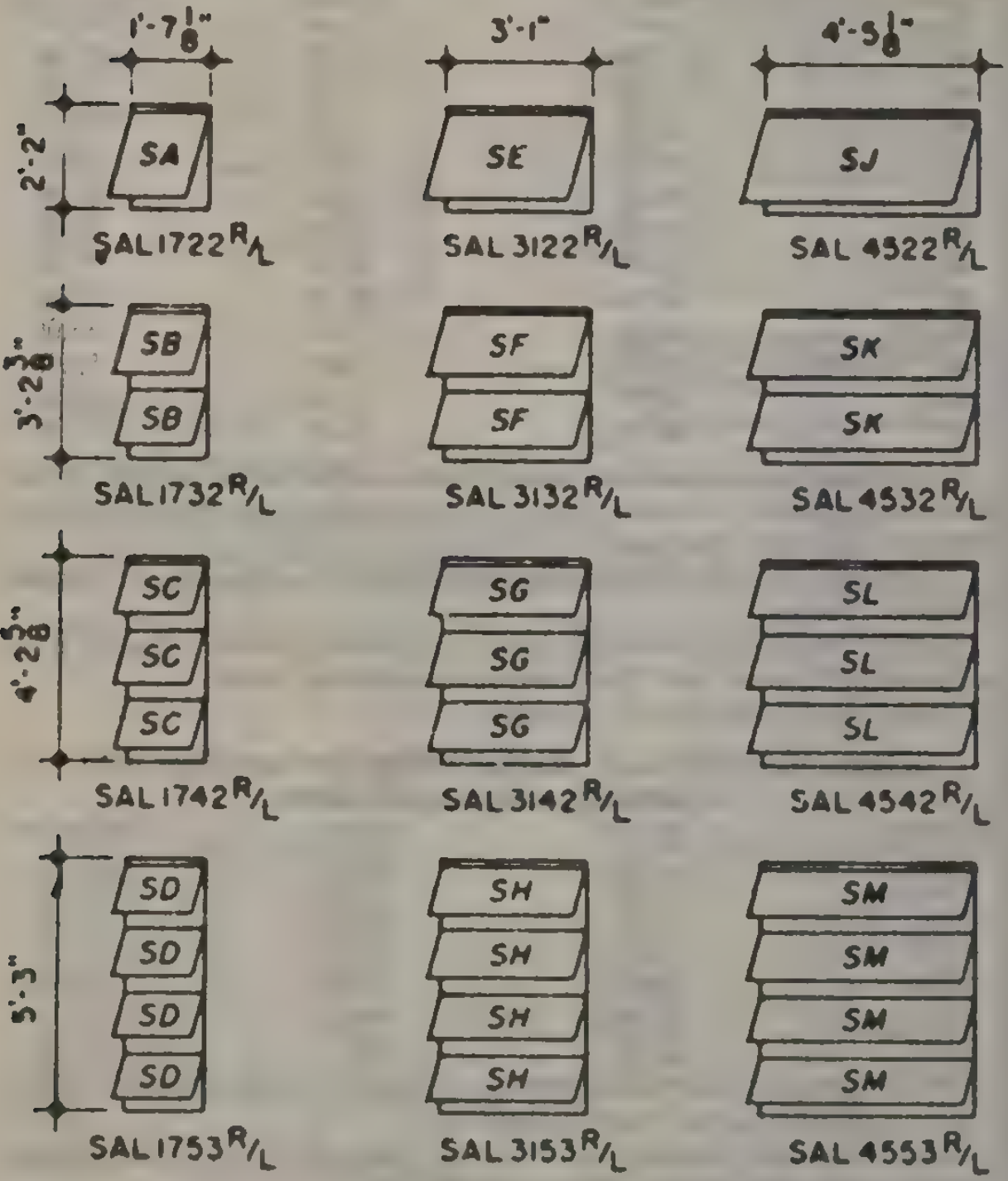
Window Type	Window Price	Window Type	Window Price
4022	$20.00	5042	$23.70
4032	21.50	5053	25.40
4042	22.70	6022	21.70
4053	24.00	6032	23.80
5022	21.00	6042	25.40
5032	22.00	6053	27.10

Prices are for four sided frames shipped knocked down. Glass, putty and glazing are not included.

Prices include glazing bead for $\frac{1}{4}$" glass or 1" insulating glass as required. Add for special width $1.60.

Zone "A" Prices of Mullions and Fins

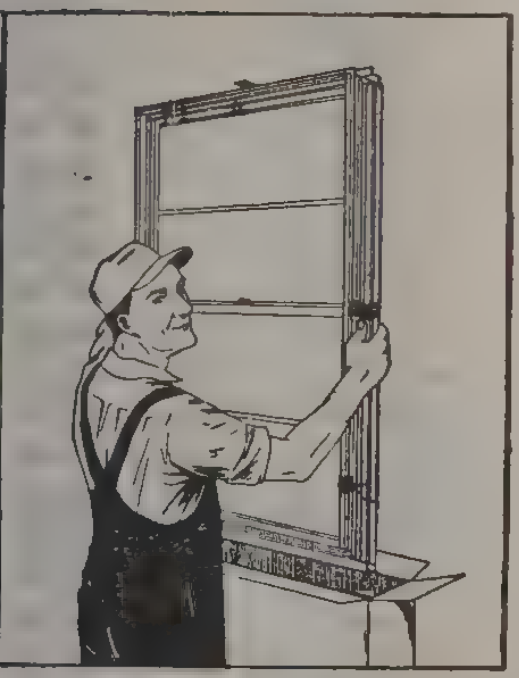
Window Height	Vertical Members Mullion Std. "T"	For Frame Constr. Fin Ea. Jamb
2'-2"	$2.20	$1.60
3'-2$\frac{3}{8}$"	2.70	1.90
4'-2$\frac{5}{8}$"	3.20	2.20
5'-3"	3.80	2.50

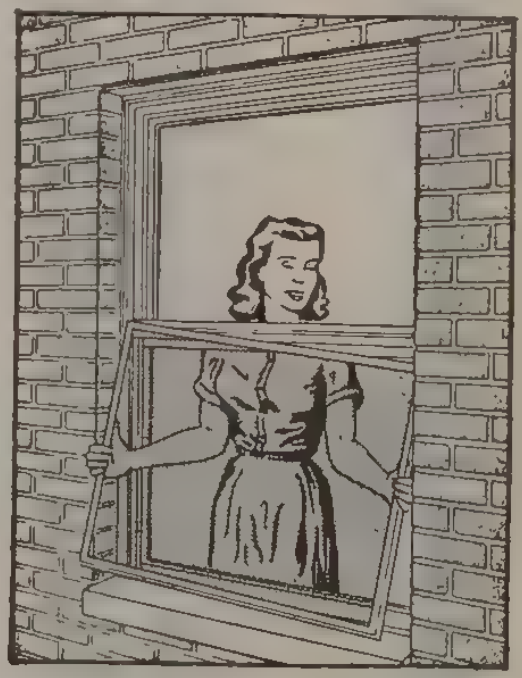


Aluminum Awning Windows

Zone "A" Prices of Mullions and Fins—Continued

Window Width	For Frame Constr. Fin Ea. (Head or Sill)
1'-7⅛"	$1.20
3'-1"	1.60
4'-5⅛"	1.90
PW40	2.20
PW50	2.50
PW60	2.90





Aluminum Double Hung Windows and Screens

Zone "A" Prices of Aluminum Double Hung Windows

Prices of windows include silicone-treated wool-pile weather-tripping, spiral, sash balances, glazing clips, standard anchors, mullion screws and window hardware consisting of sash lock, keeper and pull down for upper sash. Glass, putty and glazing are not included.

All windows are finished with a coat of water clear lacquer for protection from mortar and plaster.

Screens have extruded or rolled aluminum frame sections and are wired with 18x14 mesh aluminum cloth. Screens consist of full or half panels to allow for full or half-length screening as desired. Prices include all necessary installation hardware.

Storm sash are furnished glazed with single strength glass set in a plastic seal. All points of contact with window frame are insulated. Prices include all necessary hardware for installation.

Picture windows are shipped knocked down. Picture windows are designed to receive ¼" single glass or ½", ¾" or 1" insulating glass if specified. Prices include necessary assembly and installation hardware.

Zone "A" Prices of Aluminum Double Hung Windows

Window Type	2-Lt. Top 2-Lt. Bot.	6-Lt. Top 6-Lt. Bot.	Two Light
2030	$42.00	$45.00	$41.30
2830	44.00	48.00	43.10
3030	46.00	50.00	45.20
3430	47.00	51.00	46.10
3830	49.50	53.00	48.10
2038	45.00	47.50	44.40
2838	46.00	50.10	44.20
3038	48.00	52.00	46.20
3438	48.50	52.60	47.30
3838	49.50	53.70	49.30
2044	45.00	47.90	43.80
2844	47.50	51.70	46.70
3044	48.60	52.90	47.80
3444	49.60	53.90	48.80
3844	51.60	54.90	50.80
2050	47.00	49.90	46.80
2850	49.10	53.40	48.30
3050	50.10	54.50	49.30
3450	51.20	55.70	50.40
3850	53.30	57.30	52.50
*2860	51.10	55.70	50.30
3060	53.20	57.80	52.40
3460	48.00	52.80	47.20

*Single hung.

Zone "A" Prices of Aluminum Fins and Trim or Brick Molds

	Height of Window				
	3'-1⅝"	3'-9⅝"	4'-5⅛"	5'-1⅛"	5'-9⅛"
Jamb fin and trim or brick mold, per pair	$2.20	$2.50	$2.75	$3.00	$3.25

	Width of Window					
	2'-0½"	2'-4½"	2'-8½"	3'-0½"	3'-4½"	3'-8½"
Head Section	$0.60	$0.65	$0.75	$0.80	$0.85	$0.90
Sill Section	.50	.55	.60	.65	.75	.80

Zone "A" Prices of Aluminum Screens, Storm Sash and Inside Casings for Aluminum Double Hung Windows

Window Type	Half Screen	Full Screen	Storm Sash 2-Piece	Inside Casing
2031	$4.60	$ 5.65	$21.90	$ 7.50
2431	4.85	6.00	22.80	7.70
2831	5.15	6.45	23.75	8.10
3031	5.35	6.95	25.15	8.50
3431	5.55	7.40	26.60	8.70
3831	5.70	7.80	28.30	9.10
2039	4.80	6.15	22.80	8.20
2439	5.15	6.60	24.00	8.50
2839	5.45	7.10	25.65	8.80
3039	5.70	7.60	26.55	9.20
3439	5.95	8.30	28.45	9.40
3839	6.25	8.95	30.45	9.80
2045	5.10	6.70	24.00	8.60
2445	5.40	7.20	25.65	8.80
2845	5.75	7.80	25.55	9.20
3045	6.05	8.35	28.45	9.50
3445	6.35	9.25	29.85	9.80
3845	6.65	10.10	31.80	10.20
2051	5.45	7.35	25.65	9.10
2451	5.75	7.95	26.55	9.30
2851	6.05	8.50	28.45	9.70
3051	6.40	8.15	29.85	10.00
3451	6.75	10.25	31.80	10.20
3851	7.10	11.05	35.70	10.60
2059	5.80	7.90	26.55	9.70
2459	6.05	8.55	28.45	9.90
2859	6.30	9.25	29.85	10.30
3059	6.80	10.15	31.80	10.60
3459	7.15	11.15	35.70	10.90
3859	7.55	12.05	36.10	11.30

Zone "A" Prices of Aluminum Picture Windows for Use with Aluminum Double Hung Windows

Window Type	Price	Window Type	Price
40P31	$19.00	40P51	$23.00
44P31	19.90	44P51	23.50
40P39	20.30	48P51	24.10
44P39	21.80	*50P51	24.60
48P39	22.30	56P51	25.20
50P39	22.80	*62P51	26.50
40P45	23.20	*610P51	27.50
*42P45	23.50	40P59	24.40
44P45	23.70	44P59	24.90
48P45	24.20	48P59	25.40
*410P45	24.50	50P59	25.90
50P45	24.70	*56P59	26.80
*56P45	25.60	*62P59	28.00
*62P45	26.80	*610P59	29.10
*610P45	27.80		

*These sizes are set up (standard) for insulated glazing.

Prices are for units for single glazing. For double glazing, add $3.00 per unit.

Zone "A" Prices of Aluminum Horizontally Sliding Windows

Prices of windows include silicone-treated wool-pile weatherstripping, and integral fin. Prices are for frames and sash assembled and glazed.

All frame and sash members are cleaned, caustic etched and coated with methacrylate-type lacquer at the factory.

Screens are aluminum, covering half of window opening, and are easily installed and removed from inside.

Storm sash are installed same as screens and are two piece SSB glazed.

Window Type	Window Price	Half Screen	2-Piece Storm Sash	Inside Casing
2020	$27.90	$4.20	$22.50	$ 8.60
3020	30.00	5.55	24.50	9.50
4020	31.80	4.80	26.50	9.10
5020	34.10	5.15	27.90	10.20
6020	36.30	5.40	30.80	11.20
3030	39.60	5.00	28.40	8.80
4030	41.90	5.45	32.20	9.90
5030	44.80	5.85	35.00	11.00
6030	46.90	6.45	37.80	11.90
4040	46.00	6.10	35.40	11.00
5040	49.80	6.65	38.80	12.00
6040	53.60	7.30	44.30	13.50

Zone "A" Prices of Aluminum Picture Windows with Horizontally Sliding Flankers

Picture window prices are for frames and sash assembled and glazed.

Screen prices include two per unit.

Storm sash prices are for three piece glazed.

Window Type	Window Price	2-Piece Screens	3-Piece Storm Sash	Inside Casing
7020	$56.50	$ 8.60	$46.90	$15.40
8020	59.30	8.35	49.00	16.00
9020	65.70	8.35	53.90	18.40
7030	70.60	8.75	58.00	16.90
8030	74.20	9.80	61.70	18.20
9030	80.40	9.80	65.70	19.60
7040	83.20	9.90	67.30	18.40
8040	86.00	11.30	70.40	19.50
9040	95.60	11.30	74.20	21.00

Zone "A" Prices of Industrial Doors and Frames

Prices include all mortising, reinforcing, drilling and tapping for standard mortise items of hardware.

Frame prices include masonry anchors, and hardware preparation.

Doors and frames are bonderized and given a coat epoxy base primer baked on.

Zone "A" Prices of Swing Type Flush Panel Doors

Door Type Single Doors	18 Ga. Door Price	20 Ga. Door Price	5¾"x16 Ga. Frame Price
2068	$61.70	$34.10	$15.70
2468	63.00	36.20	15.80
2668	64.40	37.20	15.90
2868	65.80	38.30	16.00
3068	67.20	40.30	16.20
3468	69.60	42.70	16.40
2070	62.90	34.90	16.20
2470	64.30	36.90	16.30
2670	65.60	38.00	16.40
2870	67.00	39.10	16.50
3070	68.40	41.20	16.70
3470	70.70	44.20	16.90
3670	72.10	45.30	17.00
3870	73.20	46.00	17.10

Zone "A" Prices of Swing Type Flush Panel Doors—Continued.

Door Type Double Doors	18 Ga. Door Price	20 Ga. Door Price	5¾"x16 Ga. Frame Price
4068	$123.40	$68.20	$17.70
4868	126.00	72.40	18.10
5068	128.80	74.40	18.30
5468	131.60	76.60	18.50
6068	134.40	80.60	18.80
6868	139.20	85.40	19.20
4070	125.80	69.80	18.30
4870	128.60	73.80	18.70
5070	131.20	76.00	18.90
5470	134.00	78.20	19.10
6070	136.80	82.40	19.40
6870	141.40	88.40	19.80
7070	144.20	90.60	20.00
7470	146.40	92.00	20.20

Add $25.00 to $30.00 for glazed upper section.

Package Steel Doors and Frames

Package unit steel doors and frames ("A" and "B") label are stocked for immediate delivery by several manufacturers.

Stock sizes are: 3'-0"x6'-8" and 3'-0"x7'-0". Complete package prices are $150.00 for "A" label and $145.00 for "B" label.

Package includes: door, 16 ga. frame, butts, locksets and closer.

Zone "A" Prices of Steel Frames for 1⅜" Doors

Prices include 18 gauge frame, "T" anchors and hardware preparation.

Frame Size Single Swing	Prices 3" Depth	4½" Depth	5½" Depth
1668	$15.10	$12.70	$13.40
2068	15.30	12.90	13.60
2468	15.50	13.00	13.80
2668	15.60	13.10	13.90
2868	15.70	13.20	14.00
3068	15.80	13.40	14.10
1670	15.90	13.50	14.20
2070	16.10	13.70	14.40
2470	16.30	13.80	14.60
2670	16.40	13.90	14.70
2870	16.50	14.00	14.80
3070	16.60	14.20	14.90

Zone "A" Prices of Steel Frames for 1⅜" Doors—Continued.

Frame Size	Prices 3" Depth	4¾" Depth	5¾" Depth
Double Swing			
5068	$17.20	$14.60	$15.50
5468	17.40	14.80	15.70
6068	17.70	15.10	16.00
5070	18.40	15.80	16.70
5470	18.60	16.00	16.90
6070	18.90	16.30	17.20

Add $1.10 ea. for frame door closer reinforcement.

Zone "A" Prices of Hardware

Item	Price
Cylindrical Locksets	
Std. Duty	$ 6.00-$ 15.00
Heavy Duty	22.00- 41.00
Mortise Locksets	
Heavy Duty	19.00- 48.00
Push-Pull Sets	14.00- 88.00
Anti-Panic Device	96.00- 205.00
Hinges (Each)	
Steel Plain	1.60- 2.10
Steel B.B.	3.90- 5.30
Bronze B.B.	7.00
Door Closers	
III	30.00- 63.00
IV	36.00- 70.00
V	48.00- 81.00
Surface Bolt	4.30- 9.00
Kick Plate	3.00- 12.50
Door Stops	1.70- 9.70
Thresholds	
Alum.	3.50- 11.00
Bronze	12.30- 34.00

Steel Bifold and Sliding Closet Doors and Frames

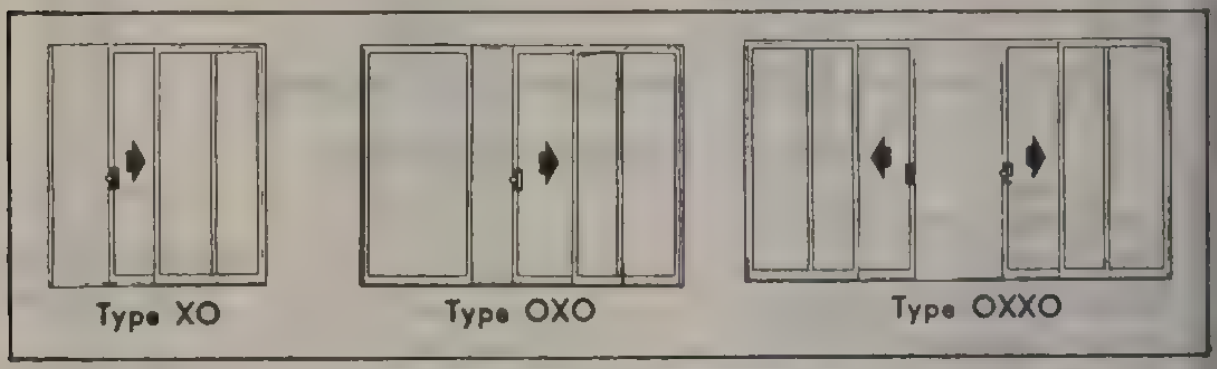
Steel sliding closet doors may be installed in openings with wood jambs and heads or in openings with steel frames. Each sliding door package unit includes two door panels, header, jamb and track sections and all necessary hardware for installation.

Frames are identical in appearance, construction and assembly to frames for residential steel swing doors, previously listed, and are also available in two depths, 5¼" and 6¼".

All doors and frames are bonderized and painted one prime coat of gray paint, oven-baked.

Zone "A" Prices of Steel Sliding Closet Doors and Frames

Size of Opening	Prices Flush	Louvered	Half Louvered	Frame
3'-0"x6'-8"	$19.50	$21.00	$26.50	$13.50
4'-0"x6'-8"	25.00	26.00	30.00	13.50
5'-0"x6'-8"	27.00	28.00	35.00	13.50
6'-0"x6'-8"	29.00	31.00	38.00	13.50



Aluminum Sliding Glass Doors

Aluminum Sliding Glass Doors

Aluminum sliding glass doors are available in several types, as illustrated, for glazing with crystal glass or ⅜" insulated glass. "X" indicates sliding panel; "O" indicates a fixed panel.

Frame, glazing bead and door members are heavy aluminum extrusions. Door sections move upon bottom mounted, ball bearing, grooved brass rollers. Frames are designed with provisions for installing bottom roller, horizontally sliding type screens. Weatherstripping is mohair pile, factory mounted in channels to form a continuous double seal. Hardware includes full-grip lucite pulls and touch latch. Cylinder lock sets are available at extra cost.

Screens are made from aluminum extrusions of tubular box type section with bottom rollers and fitted with fiberglass screen.

Prices are for door units set up. Factory assembly includes attachment of all accessory parts, such as weatherstripping, roller mechanisms, latch, corner connecting brackets, bumpers, etc. Screen units are assembled. Glass and glazing, is included.

Net Prices of Aluminum Sliding Doors

Type	Frame Size	Prices Economy, Crystal Gl.	Deluxe Insulating Gl.
XO	6'-0"x7'-0"	$150.00	$325.00
OXO	9'-0"x7'-0"	185.00	400.00
OXXO	12'-0"x7'-0"	220.00	550.00

For cylinder lock set in lieu of latch, add $3.00.

Labor Erecting Aluminum Sliding Glass Doors.—Assembly and erection of aluminum sliding glass doors is simple and does not require special tools. All aluminum members are prefit, with holes drilled and connecting brackets attached. The following table gives average labor hours required for installing aluminum sliding glass doors in ordinary residential openings.

Type	Number of Doors	Number of Fixed Panels	Mechanic Hours Required for Assembly	for Erection
XO	1	1	2	6
OXO	1	2	3	8
OXXO	2	2	4	10

Performance Standards.—There are many suppliers of aluminum windows and sliding doors and it is often difficult to compare the quality of one manufacturer with that of another. To aid one's selection, the Architectural Aluminum Manufacturers Association, 35 E. Wacker Drive, Chicago 60601, publishes quality specifications and manufacturers belonging to that association affix the AAMA "Quality-Certified" label to their products attesting that it complies with the designated specification.

These specifications include the following for sliding glass doors:

SGD-B1	For residential and limited commercial applications
SGD-A2	For commercial and residential application requiring increased size or performance characteristics.
HP Series	Either of the above designations followed by "HP" indicates that the door complies with High Performance requirements.

The specifications for aluminum windows are as follows:

DH-B1	Double hung residential
DH-A2	" " commercial
DH-A3 & A4	" " monumental
C-B1	Casement residential
C-A2	" commercial
C-A3	" monumental
P-B1	Projected residential
P-A2	" commercial
P-A3	" monumental
A-B1	Awning residential
A-A2	" commercial

HS-B1 & B2	Horizontal sliding residential
HS-A2	" " commercial
HS-A3	" " monumental
J-B1	Jalousie residential
JA-B1	Jalousie-awning residential
VS-B1	Vertical sliding residential
TH-A2	Top hinged commercial
TH-A3	" " monumental
VP-A2	Vertically pivoted commercial
VP-A3	" " monumental
HP Series	Any of the above followed by "HP" indicates the window complies with High Performance requirements.

The AAMA also publishes a certified products directory with a current listing of all certified windows and sliding glass doors by company, model and maximum size approved.

CHAPTER XXVI

STRUCTURAL AND MISCELLANEOUS IRON AND STEEL, STEEL JOISTS AND ROOF CONSTRUCTION

The preparation of a structural steel estimate involves a great deal of work because of the large amount of detail required in listing the quantities from the plans, computing the weights of the various sections, making of shop drawings and detailing the steel, estimating the cost of shop fabrication, freight, trucking, and the labor cost of erecting the steel on the job.

The structural steel framework of a building usually consists of anchor bolts, setting plates, base plates, columns, girders, beams, lintels, roof trusses, etc., which are fabricated from standard shapes, such as angles, "I" beams, channels, "WF" beams and columns, plates, rods, etc., in combinations designed to give the required strength.

Estimating Quantities of Structural Steel

When estimating the quantity of structural steel required for any job, each class of work should be estimated separately, i.e., column bases, columns, girders, beams, lintels, trusses, etc., as they all involve different labor operations in fabrication.

Columns can be estimated closely by estimating the main members as shown on the plans, including bases, caps, splices, connections, etc. For columns without cover plates, figure 1½ to 3 lbs. per lin. ft. for rivet heads and 5 to 8 lbs. per lin. ft. where cover plates are used.

All standard connections can be taken from the A.I.S.C. Steel Construction Manual and be sure to include rivets and bolts for connecting steel to steel.

Plate girder details are often estimated by percentages but usually consist of stiffeners, fillers and shelf angles. The most satisfactory method is to figure all members as shown on the plans and add 2½% to 5% for rivet heads.

There is considerable more variation in roof trusses owing to the large amount of details required. These ordinarily weigh from 15% to 25% as much as the main members, while in special cases they may run as high as 25% to 35%.

Beams can be figured as shown on the plans, adding all necessary connections, which can be obtained from the latest edition of the A.I.S.C. Steel Construction Manual.

In addition to the structural framing of the building, it is often necessary for the structural steel contractor to furnish numerous miscellaneous items, such as base plates, loose lintels, anchor bolts, etc., although they are set in place by other contractors.

Items to be Included in a Structural Steel Estimate.—When preparing an estimate on structural steel, the following items should be included to obtain the erected price:

1. Cost of structural steel shapes at the mill or warehouse.
2. Freight or trucking on structural steel shapes from rolling mill or warehouse to fabricating shop.
3. Cost of making working drawings and detailing steel ready for the shop.
4. Cost of assembling and fabricating shapes into columns, girders, beams, trusses, etc. including templates in connection with same.
5. Cost of applying one or more coats of shop paint.
6. Shop overhead expense and profit.
7. Freight on fabricated steel from shop to destination.
8. Trucking on steel from shop or cars to job.
9. Cost of erecting steel, including plant rental, setting up and removing cranes, hoisting equipment, unloading steel at site, erecting steel, field riveting, welding or bolting connections.

Estimating Cost of Structural Shapes at Mill or Warehouse.—After the quantities have been listed from the plans, it will be necessary to compute the cost of the steel sections required.

All prices on structural steel are based on mill shipment from rolling mills in Pittsburgh, Birmingham, Chicago, etc., depending upon the location of the mill where the steel is purchased, plus freight or trucking from rolling mill to fabricating shop.

Where steel is wanted in a hurry, it is often necessary to purchase same from warehouse stocks, which usually costs from 3 to 12 cents per lb. more than when purchased from mills, depending upon quantity.

Another item that must be considered when pricing steel work is the base price on standard sections and the additions thereto. Example: Assuming the base price of structural shapes is $5.85 per 100 lbs. or $117.00 per ton, find the cost of 4"x4"x½" steel angles. The standard classification of extras on the following

pages shows that angles of this size cost $0.60 per 100 lbs. more than the base price or $6.45 per 100 lbs.

Warehouse prices vary from warehouse base depending upon size and quantity ordered. On orders of 30,000 lbs. or more, the decrease from base price is 70 cts. per 100 lbs. while on orders from 100 to 399 lbs. the increase over base price is $6.00 per 100 lbs.

Structural steel prices change so often, depending upon market conditions, that latest quotations should always be obtained before figuring jobs of any size.

Cost of Making Working Drawings and Detailing Structural Steel.—The cost of making shop or working drawings for steel structures is usually figured by the number of sheets estimated to be required for layout, details, erection diagrams, etc. Drawings, 24"x36" should cost $150.00 to $180.00 per sheet, including drafting room overhead.

If drawing costs are reduced to a cost per ton, the unit costs will vary considerably, depending upon the type of building, weight of steel, amount of duplication, etc. The ton cost will run considerably less where fairly heavy shapes are used than on light structures using lattice columns, large lightweight trusses, etc., as the latter type of construction requires considerable detailing without involving much tonnage.

Steel skeleton construction, such as office buildings, hotels, etc., without unusual features can usually be detailed for $20.00 to $35.00 per ton.

Ordinary mill and factory buildings consisting of columns, lintels, light trusses and crane runs, requiring considerable detailing without much duplication, will cost from $30.00 to $40.00 per ton.

Theaters, churches and other structures of this class will cost from $35.00 to $55.00 per ton for details.

Shop Painting of Structural Steel.—After the steel has been fabricated it is customary to give it a coat of paint before it leaves the shop, except where steel is to be encased in concrete.

The cost of painting is usually estimated at a certain price per ton and the quantity of paint required and the surface area to be covered will vary with the class of steel. Ordinary structural beams contain 225 to 275 sq. ft. of surface per ton; plate girders 125 to 175 sq. ft. of surface per ton, while trusses contain 275 to 325 sq. ft. of surface per ton. The average for a job will vary from 175 to 225 sq. ft. per ton of steel.

A gallon of paint will cover 400 to 500 sq. ft. of surface, depending upon the kind of paint used.

Sufficient paint and labor necessary to paint one ton of structural steel (200 sq. ft.) with one shop coat of paint should cost as follows:

	Hours	Rate	Total	Rate	Total
0.45 gal. paint		$.....	$.....	$8.00	$3.60
Labor	1.33			5.00	6.67
Cost per ton	1.33		$.....		$10.27

Shop Overhead Expense and Profit.—After the actual cost of the various items making up a structural steel estimate have been computed, including shop drawings, assembling and fabricating, shop painting, etc., it will be necessary to add for shop overhead expense and profit. This includes such items as office expense, rent, estimating, interest, depreciation, insurance, advertising, etc., and will vary with the shop and the amount of work on hand. Drafting room overhead will vary from 40% to 60% of the actual cost of the work, while shop overhead will often be 100% to 120% the actual cost of fabrication. These items have been included in the drafting room and shop fabrication costs given, but to this it will be necessary to add 10 percent for business administration, office overhead and sales expense, plus 10 percent additional on the total cost for profit.

Basis for Estimating All Classes of Structural Steel Work

Every structural shop has constant or fixed costs that must be considered before estimating the detailed fabricating operations. The following items should be computed before adding the various shop operations required for fabricating the different members.

Approximate Constant or Fixed Costs	Price per 100 lbs.
Base price of steel, f.o.b. Pittsburgh or Chicago	$6.50
Freight or trucking on steel from rolling mill to structural shop	.60*
Cost of structural steel, f.o.b. structural shop	$7.10
Shop handling charge which includes unloading steel from cars or trucks upon arrival and loading cars or trucks after fabrication	.30
Tonnage Charges—Painting structural steel in shop	.55
Handling structural steel in shop	.30
Cutting structural shapes to lengths	.40
Shop Drawings (varies from $8.00 to $50.00 per ton) see explanation on previous pages, average cost	.80**
Total Constant or Fixed Costs	$9.45

*Varies according to freight or trucking. **Varies accordng to type of building.

The above constant or fixed costs must be included in every estimate before adding special fabrications necessary.

Cost of Fabricating Structural Steel.—The cost of fabricating structural steel varies widely, depending upon the type of building, amount of duplication, weight of structural members, number of fabricating operations necessary, etc., as the cost of fabricating light steel members usually runs considerably higher than heavier members.

The following gives approximate costs, including shop overhead, of the various shop operations and classifications:

Beam and Channel Punching Only.—Where beams and channels are punched only, without any other operation, estimate as follows:

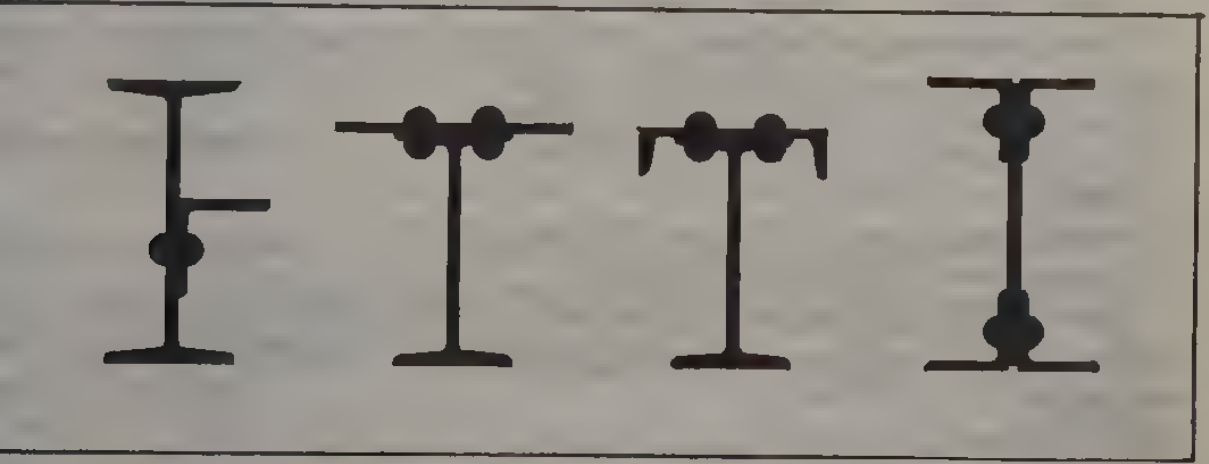
	Price per 100 lbs.
6″ to 10″ beams and channels, punching only	$2.70
12″ to 18″ beams and channels, punching only	1.85
Over 18″ beams and channels, punching only	1.60

Beams and Channels Framed with Connections.—When beam and channel sections are punched and framed with the necessary connections, estimate as follows:

	Price per 100 lbs.
Up to 10″ beams and channels	$4.90
12″ to 18″ beams and channels	3.40
Over 18″ beams and channels	2.70

Beam and Angle Framing with Shelf Angles.—Where I-beams are framed with shelf angles as illustrated, estimate as follows:

	Price per 100 lbs.
Up to 10″ beams with shelf angles	$4.65
12″ to 18″ beams with shelf angles	3.00
Over 18″ beams with shelf angles	2.75



Beam Framing with Shelf Angles | Beam Framing with Plates or Channels | Built-up Plate Girder

Beam Framing with Plates or Channels.—Where beams are framed having a plate or channel riveted to same as illustrated, estimate as follows:

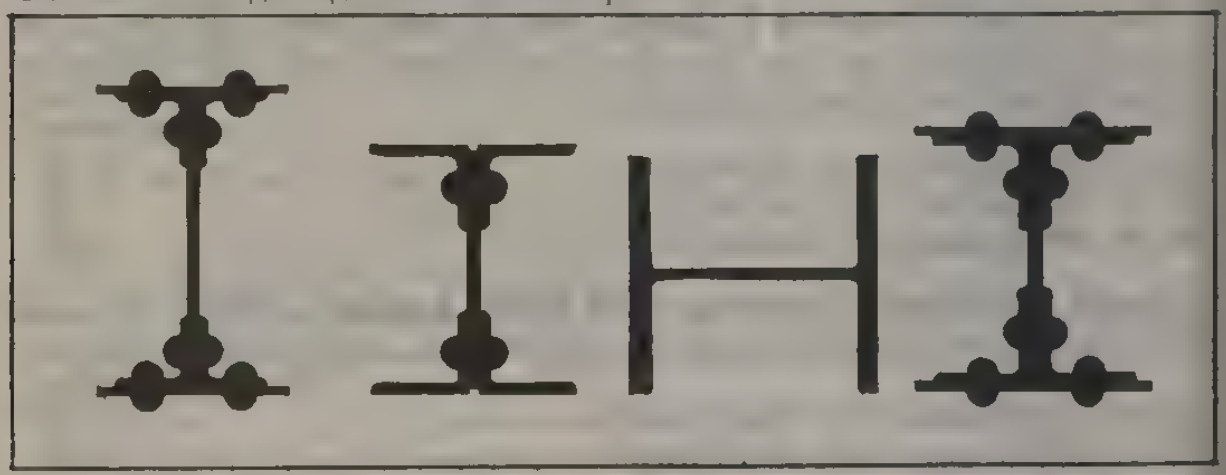
	Price per 100 lbs.
Up to 10" beams	$7.50
12" to 18" beams	5.00
Over 18" beams	3.80

Built-Up Plate Girders.—When estimating the cost of built-up plate girders consisting of plates and angles as illustrated, estimate as follows: $7.00

Built-Up Plate Girders with Cover Plates.—Built-up plate girders consisting of plates, angles and cover plates, as illustrated, should be estimated, per 100 lbs. $8.25

Plate and Angle Columns.—Structural steel columns built-up of plates and angles as illustrated, should be estimated as follows:

	Price per 100 lbs.
Columns weighing up to 50 lbs. per lin. ft.	$9.60
Columns weighing from 50lbs. to 100 lbs. per lin. ft.	6.25
Columns weighing over 100 lbs. per lin. ft.	5.10



Built-up Plate Girder with Cover Plates | Built-up Plate and Angle Columns | Rolled WF Sections | Built-up Plate and Angle Columns with Cover Plates

Plate and Angle Columns with Cover Plates.—Structural steel columns built-up of plates and angles with cover plates as illustrated, should be estimated as follows:

Not including Weight of Cover Plates	Price per 100 lbs.
Columns weighing up to 50 lbs. per lin. ft.	$12.00
Columns weighing 50 lbs. to 100 lbs. per lin. ft.	8.70
Columns over 100 lbs. per lin. ft.	7.60

Rolled WF Columns.—Structural steel columns consisting of rolled wide flange and similar sections as illustrated, should be estimated as follows:

	Price per 100 lbs.
WF Columns, up to 6"	$7.60
WF Columns, 8"	6.50
WF Columns over 8"	5.50

Price per 100 lbs.

Crane Columns.—Structural steel columns for supporting crane runs, etc. $8.50

Laced Columns.—Structural steel columns with laced cross bracing $10.20

Steel Roof Trusses.—When estimating the cost of structural steel roof trusses, the fabricating cost will vary with the weight of the trusses, as follows:

	Price per 100 lbs.
Steel roof trusses, weighing up to 1,000 lbs. each	$14.00
Steel roof trusses, weighing from 1,000 to 2,000 lbs. each	11.80
Steel roof trusses, weighing from 2,000 to 3,000 lbs. each	10.00
Steel roof trusses, weighing from 3,000 to 4,000 lbs. each	8.00
Steel roof trusses, weighing over 4,000 lbs. each	7.10

Knee Bracing.—Fabricating cost per 100 lbs. 12.70

Angle Struts.—Fabricating cost per 100 lbs. 10.70

"X" Framing and Bracing.—Fabricating cost per 100 lbs. 7.50

Tie Rods.—Tie rods $\frac{5}{8}$" rounds, fabricating cost per 100 lbs. 22.00

Bracing Rods.—Bracing rods of $\frac{3}{4}$" to 1" rounds, fabricating cost per 100 lbs. 13.90

Fabricating Steel Bins, Hoppers and Similiar Plate Work.—When estimating the cost of fabricating steel plate work, such as steel bins, hoppers and work of this class, figure the fabricating cost, per 100 lbs. 14.00

Floor Plates, Plain or Checkered.—Estimate the weight of the material in the usual manner.

The material usually costs 10 to 15 cts. per lb. depending upon market conditions and the cost of fabricating should be figured at 5 to 20 cts. per lb. additional.

Make Up of a Complete Structural Steel Price

The following items should be included to obtain the total price for structural steel delivered f.o.b. cars or job:

	Price per 100 lbs.
Total steel price, f.o.b. fabricating shop, including constant or fixed costs, as given on previous pages	$ 9.45*
Shop labor and fabrication cost (varies according to operations required, as given on previous pages), varies...	6.50**
Total direct shop costs	$15.95

*This item varies as described on previous pages.

**Fabricating costs vary according to amount of shop labor required as given under cost of the various fabricating operations.

Make Up of a Complete Structural Steel Price—Continued

Brought Forward	$15.95
Business administration, overhead and sales expense, 12%	1.90
	$17.85
Profit on total cost, including overhead, 10%	1.80
	$19.65
Transportation from shop to job—varies	.65
Price of structural steel, delivered at job	$20.30

Mill and Shop Inspection of Structural Steel.—Where the structural steel is inspected by one of the testing laboratories, the usual charges for this work are as follows:

Mill inspection is usually figured at $1.25 to $1.50 per ton and shop inspection from $2.00 to $2.50 per ton. Where both mill and shop inspection are let to one firm, a common price is $2.50 to $3.50 per ton for both.

Field Inspection of Structural Steel.—Where field inspection of the erection and riveting of the structural steel is required, figure $240.00 to $300.00 per week for salary and expenses of a field inspector, plus transportation to and from job.

Erection of Structural Steel

The field cost of handling and erecting structural steel is difficult to estimate. This is due to a number of reasons, such as weather conditions, strikes, delays in receipt of materials, storage facilities, size and type of building, equipment available, labor conditions, amount of riveting, welding, etc.

Any one of the above items may cause a considerable variation in the estimated labor costs and for that reason should be carefully considered when preparing the estimate.

Hauling Structural Steel From Shops or Cars to Job.—The cost of hauling structural steel from the shop or cars to the job will vary with the facilities for loading trucks, distance of haul, weight of steel members, etc.

A motor truck will haul from 5 to 12.5 tons of steel per load.

The average cost of hauling structural steel is $6.00 to $8.00 per ton.

Plant and Equipment for Steel Erection.—The equipment required for steel erection will vary considerably with the size and type of building.

Skeleton frame buildings up to 100'-0"x100'-0" in size will require one derrick to unload the steel from the trucks and erect it in place, while buildings of irregular shape, such as "L" shape, "U" shape, etc., will probably require additional derricks, as one derrick can handle a job 100'-0"x100'-0" but if

ne job is 75'-0"x125'-0" it will probably require two derricks to et the job, while a "U" shape building may require 3 derricks. Where the buildings have setbacks at certain story heights, s required by many cities, it will often require 2 derricks on he job, one to unload the steel and hoist it from the street nd another to set the steel.

At the present time it costs $1,500.00 to $2,000.00 to set up and emove a hoisting engine, derrick, compressor outfit, etc., for one derrick job, with additional derricks at approximately the ame cost.

On buildings covering considerable ground area, such as high chools, auditoriums, mill and factory buildings, etc., up to 3 or stories high, it is often more economical to use a derrick rane, mounted on a motor truck or railroad car, depending pon location of the job. Where a movable crane can be used o advantage, that is the most economical method to use, as he crane can be moved about at slight expense.

Steel Erection Contractors.—Most structural steel is erected y contractors making a specialty of steel erection. These con- ractors can erect structural steel much cheaper than the average eneral contractor because they have well organized crews of orkmen specializing in this branch of work, they also have on and the most modern equipment, such as caterpillar cranes, ruck cranes, lightweight and modern air tools, such as grinders, rills, rivet busters, impact wrenches, welding machines, and ther special tools which are furnished to the job as needed and eldom figured in the job cost; to say nothing of the background f experience of its organization and men.

When subletting structural steel work, it will be necessary to dd for workmen's compensation and liability insurance, social ecurity and unemployment taxes, welfare contributions, plus he steel erection contractor's overhead expense and profit, which ay vary from 25% to 40% of the direct labor costs.

Erecting Structural Steel in Skeleton Frame Buildings.—When figuring erection on a job of this type, consider carefully he amount of equipment, number of derricks, etc., required, s described on the previous page.

On a one derrick job, an erection gang should unload, handle, rect and rivet 10 to 12 tons of steel per 8-hr. day, at the follow- ng labor cost per ton:

Erection gang	Hours	Rate	Total	Rate	Total
iron worker "pusher"..	0.75	$....	$.....	$7.60	$ 5.70
ir. wkrs. "hooking on"..	1.50	.....	.....	7.10	10.65
ir. wkr. giving signals.	.75	.....	.....	7.10	5.33
Carried Forward	3.00		$.....		$21.68

	Hours	Rate	Total	Rate	Total
Brought Forward	3.00	$....	$....	$....	$21.68
2 ir. wkrs. "connecting"..	1.50	.....	...	7.10	10.65
1 hoisting engineer.....	.75	.....	.....	6.00	4.50
Riveting gang					
1 ir. wkr. heating rivets..	.75	.....	.....	7.10	5.33
1 ir. wkr. catching rivets.	.75	.....	.....	7.10	5.33
2 ir. wkrs. driving rivets.	1.50	.....	.....	7.10	10.65
1 compressor engr.	.50	.....	.....	6.00	3.00
Cost per ton	8.75		$.....		$61.14

Add for workmen's compensation and liability insurance, plu erection contractor's overhead expense and profit.

Above costs include time setting up and removing derricks engines, compressor outfit, etc.

If the structural connections are bolted instead of riveted deduct $4.00 to $5.00 per ton.

Erecting Structural Steel in Wall Bearing Buildings.—O wall bearing buildings the ends of all beams and channel usually rest on the exterior masonry walls while the interio framing is carried on masonry walls or structural steel columns Field connections are usually bolted. The steel on a job of thi kind is usually placed using a 6"x6", 8"x8" or 10"x10" pole abou 40'-0" long.

The labor setting up a hand operated derrick, ready to star erection should cost as follows:

	Hours	Rate	Total	Rate	Total
Iron worker	40	$.....	$.....	$7.10	$284.00

If the steel can be set using a light Sasgen or "monkey" der rick, the derrick can be set up in 6 to 8 man hours.

After the derrick is in place, nine men working togethe should handle and erect (including bolted connections) 7 to tons of steel per 8-hr. day, at the following labor cost per ton

	Hours	Rate	Total	Rate	Total
Foreman	1	$.....	$.....	$7.60	$ 7.60
Iron worker	8	.....	.....	7.10	56.80
Cost per ton	9		$.....		$64.40

Add for workmen's compensation and liability insurance, plus erection contractor's overhead expense and profit.

Erecting Lightweight Steel for Mill Buildings, Foundries, Auditoriums, Etc.—On light constructed steel buildings, such as machine shops, foundries, mill buildings, garages, auditoriums, etc., where the structural steel consists of steel columns and lightweight roof trusses, requiring considerable handling to set only a small tonnage, the labor costs run higher than on average skeleton frame construction.

Erecting Structural Steel Using Caterpillar Mounted Cranes

Where the tonnage is sufficient, a caterpillar crane or a truck crane should be used for setting the steel, as it is more flexible than a stiff leg or guy derrick and can be easily moved from place to place.

After the crane has been delivered at the job, the labor unloading, handling, erecting and riveting one ton of steel should cost as follows:

Erection gang	Hours	Rate	Total	Rate	Total
1 iron worker "pusher"..	1.0	$.....	$.....	$7.60	$ 7.60
5 iron workers	5.0	.....	.....	7.10	35.50
1 hoisting engineer	1.0	.....	.....	6.00	6.00
Riveting gang					
4 iron workers	4.0	.....	.....	7.10	28.40
1 compressor engineer ...	0.5	.....	.....	6.00	3.00
Cost per ton	11.5		$.....		$80.50

To the above costs, add crane rental, workmen's compensation and liability insurance, plus erection contractor's overhead expense and profit.

On small buildings of this type where a gin pole or other hand operated derricks are used for handling and hoisting the steel, figure about the same labor cost per ton as given above.

The above illustration shows the great advantage of using caterpillar mounted portable cranes in the erection of structural steel in certain types of structures where the height does not exceed 100'-0" to 125'-0", and on structures that cover a considerable ground area, as they are easily moved and the entire operation is much more flexible than where fixed-type derricks are used.

Erecting Steel Bins, Hoppers and Similar Plate Work.—When erecting steel bins, material hoppers and similar plate work, an erection crew consisting of 5 iron workers and an engineer should erect in place and bolt, 4 to 5 tons of steel a day at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
1 hoisting engineer	2	$.....	$.....	$6.00	$12.00
5 iron workers	10	.....	.....	7.10	71.00
1 hoisting engineer	2	.....	.....	6.00	12.00
Cost per ton	14		$.....		$95.00

Riveting or welding the joints or seams in hopper work will run from $40.00 to $50.00 per ton, in addition to the erection costs.

Add for workmen's compensation and liability insurance, plus erection contractor's overhead expense and profit.

Riveting Steel After Erection.—The labor cost of riveting steel after erection will vary with the type of construction and the weight of the structural members. Light constructed jobs usually require fewer rivets at each connection than heavy constructed jobs and require more moving of scaffold to drive the same number of rivets. The more rivets that can be driven from one scaffold, the greater the number driven per day.

On light constructed buildings, a riveting gang should drive 275 to 325 rivets per 8-hr. day, at the following labor cost per 100:

	Hours	Rate	Total	Rate	Total
Ir. wkr. heating rivets	2.6	$.....	$.....	$7.10	$18.46
Ir. wkr. catching rivets	2.6	.....	.....	7.10	18.46
Ir. wkr. driving rivets	5.2	.....	.....	7.10	36.92
Compressor engineer	1.3	.....	.....	6.00	7.80
Cost per 100 rivets	11.7		$.....		$81.64
Cost per rivet					.82

On steel skeleton buildings or other structures of this type, where the members consist of "I" beams, channels, girders, etc., a riveting gang should drive 325 to 375 rivets per 8-hr. day, at the following labor cost per 100:

	Hours	Rate	Total	Rate	Total
Ir. wkr. heating rivets	2.25	$.....	$.....	$7.10	$15.98
Ir. wkr. catching rivets	2.25	.....	.....	7.10	15.98
Ir. wkr. driving rivets	4.50	.....	.....	7.10	31.96
Compressor engineer	1.13	.....	.....	6.00	6.78
Cost per 100 rivets	10.13		$.....		$70.70
Cost per rivet			.....		.71

The variation is due to the number of rivets driven from one scaffold and the amount of moving necessary.

The cost of rivets will vary with their size and length, as steel of different thicknesses requires different size rivets. Example: when riveting steel $\frac{1}{2}$" or less in thickness, it is customary to use $\frac{3}{4}$" rivets by the required length; $\frac{3}{4}$" steel requires $\frac{7}{8}$" rivets, etc.

Bolting Field Connections.—Many of the smaller structural steel jobs, such as wall bearing buildings, etc., having only a few beams and columns, have the sections bolted together instead of riveted.

On work of this kind an iron worker should place 150 to 200 bolts per 8-hr. day, at the following labor cost per 100:

	Hours	Rate	Total	Rate	Total
Iron worker	5	$.....	$.....	$7.10	$35.50
Cost per bolt			.....		.36

ARC WELDING IN BUILDING CONSTRUCTION

The following information on Arc Welding Structural Steel has been furnished through the courtesy of The Lincoln Electric Company, Cleveland, Ohio.

Arc welding structural steel in the construction of buildings and bridges has become an established practice. To aid the structural designer in its use, the American Welding Society, the American Institute of Steel Construction and the American Association of State Highway Officials have established recommended codes and specifications governing design, fabrication

and erection of welded steel structures and applicable codes of most cities, counties and states are in accordance with them. In addition, most fabricating shops now have the equipment, personnel and experience required to fabricate steel members for welded construction and in the field, an increasing number of qualified operators are available for welding field joints during erection.

Advantages of Arc Welded Steel Design.—Advantages of arc welded steel design in building construction are lower overall construction costs; less construction noise, particularly desirable in hospital zones, residential districts, etc., and smooth, clean appearance of erected members which permits leaving structural steel exposed where desired or necessary.

Overall lower costs are realized through reduced steel material requirements and savings in foundation and exterior wall construction. When a structure with welded connections is properly designed, savings in steel material are gained from the following:

Gross section, rather than effective net section, is used for design, permitting lighter members.

Rigid connections provide continuous beam action, permitting a further reduction in member sections.

Connection steel, such as splice plates, gussets, etc., are greatly reduced—sometimes eliminated.

With beams of less depth, height of building may be reduced, saving column steel and exterior wall construction.

In addition, overall costs for detailing, fabrication, freight, trucking, handling and erection are lower due to reduced weight, fewer pieces and simplified connections.

On many structures, where designs and estimates were made for both riveted and welded construction, savings up to 15 percent on structural steel costs were obtained by using the welded method.

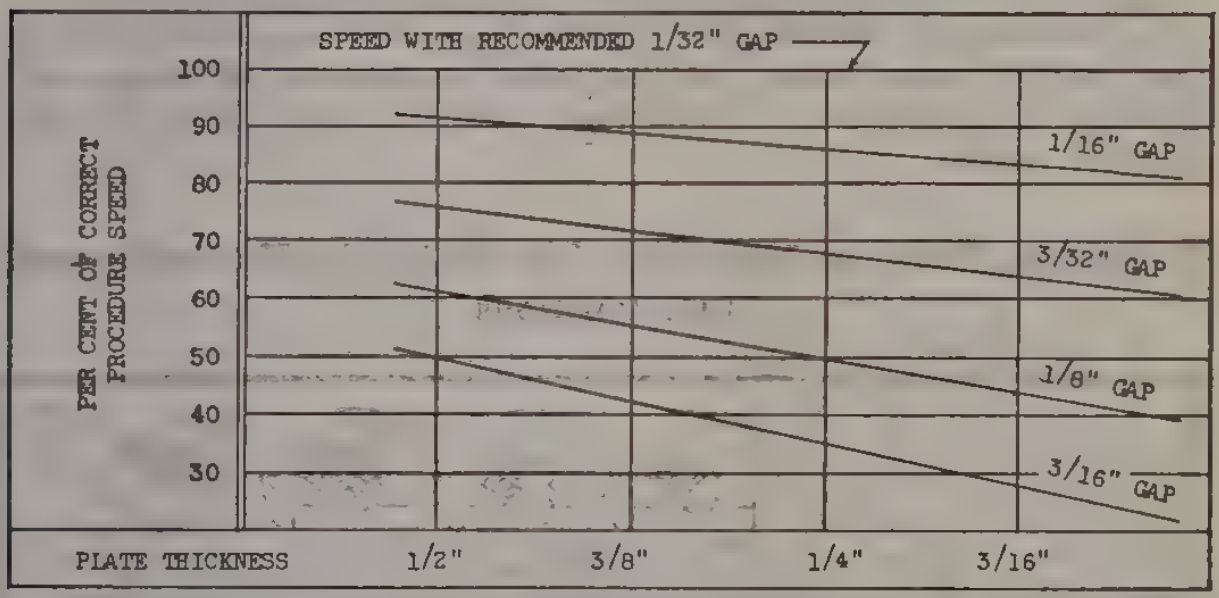
Conditions Affecting Arc Welding Costs

Best results and lowest costs are obtainable only when proper plate preparation and welding procedure is followed. The following conditions have considerable bearing on the cost and quality of welded joints.

Fit-Up.—Care in cutting, forming and handling shapes to be welded, to avoid poor fit-up, is a major factor in the cost and performance of welded joints. However, a gap of 1/64" to 1/32" is useful in preventing angular distortion and weld cracking. The accompanying graph shows how various sizes of gaps

affect welding speeds for square or grooved butt welds. Fillet welds are affected by oversize gaps in a similar manner.

Position of Joints.—The position of the joint has considerable effect on the speed and ease of welding. Wherever practical, welds should be made in the downhand position with the joint level. Vertical or overhead welds require much more time and skill.



Effect of Gap Size on Welding Speeds for Flat Butt Joints Welded on Both Sides

Foreign Matter in Joint.—Excessive scale, paint, oil, rust, etc., all tend to interfere with welding and should be removed to obtain best speeds and results.

Build-Up or Overwelding.—Any amount of weld metal in addition to that actually needed for the specified strength is useless, costly, wasteful and, in some instances, actually harmful. For butt welds, there should be just enough build-up (no more than $\frac{1}{16}$") to make sure weld is flush with the plate. Excessive build-up not only wastes weld metal but increases welding time.

Procedures for Making Various Types of Welded Joints

The following tables give procedures for making various types of welded joints usually encountered in field erection of structural steel and furnish information for calculating time and material required.

In the tables, electrodes specified are those which will make the joints at the lowest cost.

Arc speed in inches per minute is given for single pass welds and for the first pass in multiple pass welds, as the speed of the first pass is important in obtaining proper penetration.

Feet of joint welded per hour is based on actual welding time. No factor has been included for set-up, electrode changing, cleaning, moving scaffold, etc., which will vary with the job. For overall average quantities, these figures should be multiplied by an operating factor which may range from 25 to 50 percent, depending upon job conditions.

Pounds of electrode per foot of weld is the amount of electrode required to weld the joint with the recommended plate preparation, fit-up and a build-up of $\frac{1}{16}$" or less—includes normal spatter loss and 2" stub ends. Any increase in gap or build-up will greatly affect amount of electrode required and time for depositing same.

Estimating Data on Fillet and Lap Welds in Horizontal and Flat Positions

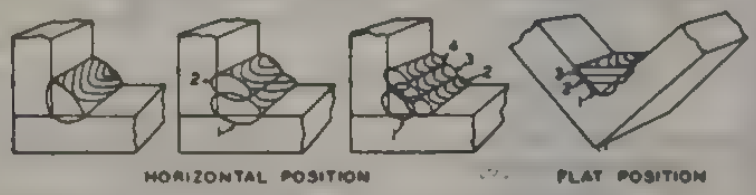


Plate Thickness (In.)	Gauge Size of Fillet (In.)	Electrode Size (In.)	Current (Amps.)	Electrode Melt-off Rate (In. per Min.)	Arc Speed (In. per Min. for First Pass)	Passes or Beads	Ft. of Joint Welded Per Hr. (100% Operating Factor)	Lbs. of Electrode Per Ft. of Weld
3/16	5/32	1/8	170	15.0	15–16	1	75–80	.10
1/4	3/16	5/32	225	14.0	15–16	1	75–80	.15
5/16	1/4	3/16	275	12.0	14–15	1	70–75	.19
3/8	5/16	1/4	350–375	9.6–10.2	12–13	1	60–65	.30
1/2	7/16	1/4	350–375	9.6–10.2	10–11	2	28–31	.57
3/4	5/8	1/4	350–375	9.6–10.2	10–11	3–4	16–14	1.34
1	3/4	1/4	350–375	9.6–10.2	10–11	5	9–10	1.86

Preparation: square edge.

Fit-Up: recommended gap, $\frac{1}{32}$".

Electrode: iron powder E6024 AC. Use E6014 AC electrodes when weldment canot be positioned close enought to flat for E6024 AC electrodes.

Estimating Data on Fillet and Lap Welds in Vertical Position, Welded Up*

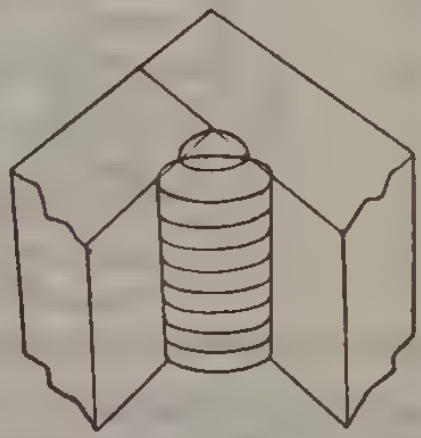


Plate Thickness (In.)	Gauge Size of Fillet (In.) ‡	Electrode Size (In.)	Current (Amp.)	Electrode Melt-off Rate (In. per Min.)	Arc Speed (In. per Min. for First Pass)	Passes or Beads	Ft. of Joint Welded per Hr 100% Operating Factor)	Lbs. of Electrode Per ft. of Weld
3/16	5/32*	5/32	140	9-1/2	10	1	50	.08
1/4	3/16	3/16	150	8	7	1	35	.14
5/16	1/4	3/16	170	8-1/2	6	1	30	.17
3/8	5/16	3/16	170	8-1/2	3.9	1	19.5	.26
7/16	3/8	3/16	170	8-1/2	2.7	2	13.5	.38
1/2	7/16	3/16	170	8-1/2	6	2	10	.52
5/8	1/2	3/16	170	8-1/2	4	2 or more	7.7	.67
3/4	5/8	3/16	170	8-1/2	4	§	5	1.1
1	7/8	3/16	170	8-1/2	4	§	2.5	2.1

*Weld 5/32" fillet vertically down. ‡T-joint welded both sides with this fillet will have plate strengh. §Total no. of passes varies with operator.

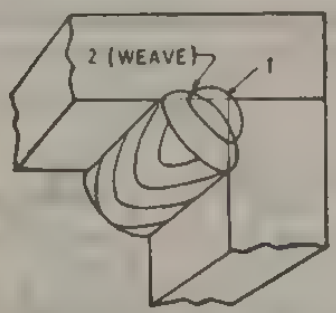
Preparation: square edge.

Fit-up: recommended gap, $\frac{1}{32}$"; maximum gap, $\frac{1}{16}$". If greater gaps must be welded, use same procedure but add width of gap to fillet size.

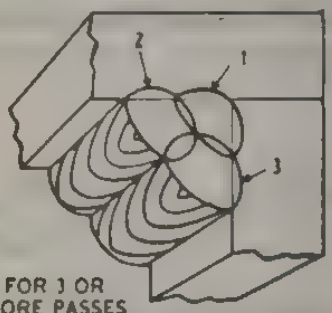
Electrode: E6010.

Polarity: electrode positive.

Estimating Data on Fillet and Lap Welds in Overhead Position



TWO PASSES



FOR 3 OR MORE PASSES

Plate Thickness (In.)	Gauge Size of Fillet (In.) †	Electrode Size (In.)	Current (Amp.)	Electrode Melt-off Rate (In. per Min.)	Arc Speed (In. per Min. for First Pass)	Passes or Beads	Ft. of Joint Welded per Hr. (100% Operating Factor)	Lbs. of Electrode Per Ft. of Weld
3/16	5/32	5/32	140	9-1/2	9	1	45	.09
1/4	3/16	3/16	160	8-1/4	7	1	35	.14
5/16	1/4	3/16	160	8-1/4	5.7	1	28.5	.18
3/8	5/16	3/16	160	8-1/4	3.7	2	18.5	.27
7/16	3/8	3/16	160	8-1/4	7-3/4	3	12.5	.40
1/2	7/16	3/16	160	8-1/4	7	§	9.2	.55
5/8	1/2	3/16	160	8-1/4	6	§	7.0	.72
3/4	5/8	3/16	160	8-1/4	6	§	4.5	1.2
1	7/8	3/16	160	8-1/4	6	§	2.2	2.3

†T joint welded both sides with this fillet will have plate strength.
§Total number of passes varies with operators.

Preparation: square edge.

Fit-up: recommended gap, $\frac{1}{32}$"; maximum gap, $\frac{1}{16}$". If greater gaps must be welded, use same procedure but add width of gap to fillet size.

Actual Welding Costs on Three Jobs.—The following are actual costs of field welding on three different jobs located in different parts of the country and will give the estimator an idea of the amount of welding and labor required.

Description	14 Story Off. Bldg.	19 Story Off. Bldg.	18 Story Hospital
Size of building on the ground.....	58'x100'	100'x100'	140'x200'
Total tonnage of steel welded, tons	1,050	1,170	2,274
Fillet per ton of steel, lineal inches	57.63	63.5	50.68
Electrode used per ton of steel, lbs.	2.5	4.0	1.7
Electric current required per ton of steel, kw. Hrs.	5.8	8.1	6.05
Weld per lb. of electrode bought, lin. inches	23.24	16.00	21.34
Welding man hours per ton of steel, hours	1.15	1.51	1.80*
Steel welded per month, per machine, tons	140.00	128.00	...
Lin. ft. fillet per 8-hr. day, per welder	33.5	28.0	36.0
Lin. ft. fillet per pound of electrode bought	1.94	1.33	1.78
Electric current required to melt one lb. of electrode, kw. Hrs.	2.94	2.90	3.63

*Includes 0.26 hrs. foreman, 0.91 hrs. welder, 0.26 hrs. helpers and 0.37 hrs. hoist. engr. time.

Miscellaneous Iron Work

Iron Stairs.—Iron stairs consisting of 10 or 12-inch channel stringers and either steel pan or cast iron (checkered) treads, figure $70.00 to $80.00 per riser for stair including platform, newel posts, pipe rail or spindle rail and field erection.

For more detailed estimate, figure the actual weight of the materials required in the stair construction and figure 50 to 60 cents per pound.

Pipe Railings.—When estimating plain pipe railing, consisting of two horizontal runs of pipe with uprights 6 ft. to 8 ft. on center, figure as follows for the various sizes, erected in place:

1¼" pipe railing, complete as described above, per 6 to 8 ft. section, including upright.....$20.00 to $25.00

1½" pipe railing, complete as described above, per 6 to 8 ft. section, including upright.....$21.00 to $26.00

2" pipe railing, complete as described above, per 6 to 8 ft. section, including upright.....$23.00 to $28.00

For each curved section or termination point that is formed to radius, add $10.00 to $15.00.

For following the rake of a stair, add $3.00 per upright.

Steel Ladders.—Straight steel ladders cost from $6.00 to $8.00 per lin. ft., erected in place. Add $20.00 to $30.00 for curved handles and platform over coping walls.

Steel Area Gratings.—Steel area gratings made of $\frac{1}{4}$"x1$\frac{1}{4}$" iron or steel bars, tenoned or riveted together, with separators through center complete with steel frames. Price per sq. ft., delivered to job.....$4.25 to $5.25

Steel Window Guards.—Window guards made with $\frac{3}{8}$"x2" horizontal bars, top and bottom and round or square upright bars spaced 4" on centers. Delivered to job.

	Approx. Price per Sq. Ft.
Window guards with $\frac{1}{2}$" round upright bars	$2.40
Window guards with $\frac{1}{2}$" square upright bars	2.60
Window guards with $\frac{5}{8}$" round upright bars	2.70
Window guards with $\frac{5}{8}$" square upright bars	2.90
Window guards with $\frac{3}{4}$" round upright bars	3.00
Window guards with $\frac{3}{4}$" square upright bars	3.25

Do not figure any opening as containing less than 15 sq. ft.

Window Guards Made of Crimped Diamond Mesh.—Window guards made with 1-inch channel iron frames and crimped diamond mesh wire. Per sq. ft., erected in place.....$2.00 to $2.70

Do not figure any opening as containing less than 20 sq. ft.

Curb Angles, Floor Frames, Trench Frames and Covers.—For miscellaneous items, such as curb angles, floor frames, trench frames and covers, etc., figure 25 to 30 cts. per lb. delivered to job.

Flagpoles.—Typical price examples of several types of flagpoles are as follows: 40'-0" ground type; swaged sectional steel, including fittings, ground tube and flashing collar. Price $500.00, erected in place and painted.

40'-0" ground type; cone tapered steel, including fittings, ground tube and flashing collar. Price $850.00 erected in place and painted.

To above prices, add cost of concrete foundation and ornamental base if required.

20'-0" roof type; swaged sectional steel, including fittings, socket plate, tension braces and flashing collars. Price $380.00, erected in place and painted. Add cost of setting anchor bolts.

12'-0" outrigger type; cone tapered aluminum, including fittings and base. Price $300.00, erected in place. Add cost of setting anchor bolts.

Ornamental Iron Entrance Rails.—Fabricated from 1¼"x¼" or 1¼"x⅜" bar stock or 1½" bar size channels for rails and ½" square bar pickets. Stock designs, delivered to job, cost $2.50 to $5.00 per lin. ft. of rail depending on amount or ornamentation. For rails following the rake of stairs, add 25 per cent. Rails made to special design may cost 2 to 3 times the above prices.

Ornamental Porch Columns.—Stock design, scrolled, wrought iron columns, with ¾"x¾" bar stock or $\frac{1}{16}$" square tubing frames and ⅜"x¼" or ½"x$\frac{3}{16}$" bar or strip stock scrolls. Flat columns, 8½" to 12" wide x 8'-0" high, $12.50 to $15.50 each. Corner columns to match flat columns, $20.25 to $30.00 each.

Stock design columns, with ¾"x¾" bar stock frames and cast iron panels, delivered to job, cost as follows:

Flat columns, 9½" to 11" wide x 8'-0" high, $28.00 to $40.00 each.
Corner columns to match flat columns, $50.00 to $60.00 each.
Brackets to match columns, $5.00 each.

Steel Stacks

Steel stack costs vary widely and are dependent on height, diameter, gauge of material, number of joints, transportation, etc. Steel stacks are usually fabricated by companies specializing in steel boiler and tank manufacturing.

When estimating a job that has a steel stack, always obtain a firm figure from a steel stack fabricator before submitting a bid on the work.

The following costs are taken from actual jobs and are given to aid the contractor in preparing preliminary estimates and for checking purposes only.

Cost of Steel Stacks.—A steel stack 26 inches in diameter and 82 feet high. The lower 42 feet of the stack was $\frac{3}{16}$-inch steel and the upper 40 feet was No. 10 tank steel. The stack was furnished in four sections with iron flange connections, cleanout door, and breeching.

The cost of the stack, not including erection, averaged as follows:

	Rate	Total	Rate	Total
2,400 lbs. $\frac{3}{16}$-in. plate	$.....	$.....	$12.00	$ 288.00
1,700 lbs. 10 ga. sheet	.....	.....	12.50	212.50
600 lbs. angle iron con. and rivets	.....	.....	15.00	90.00
Shop work, transportation and profit	.....	.....		1800.00
Total cost of stack		$.....		$2390.50
Average per lin. ft.		.....		29.18
Average per lb.		.....		.508

Another steel stack was 28 inches in diameter and 110 feet high. The lower 60 feet was ¼-inch steel and the upper 50 feet of 3/16-inch steel. The stack was furnished complete in 5 sections with cleanout door and sheet iron hood. Each section of the stack was connected with angle iron flange connections.

The cost of the stack, not including erection, averaged as follows:

	Rate	Total	Rate	Total
4,700 lbs. ¼-in. plate	$.....	$.....	$11.50	$ 540.50
2,950 lbs. 3/16-in. plate	.....	.....	12.00	354.00
800 lbs. angle iron con. and rivets	.....	.....	15.00	120.00
Hood and cleanout, 450 lbs.	.....	.....		350.00
Shop work, transportation and profit	.....	.....		3420.00
Total cost of stack		$.....		$4784.50
Average per lin. ft.		.....		43.48
Average per lb.		.....		.567

Labor Erecting Steel Stacks.—When estimating the labor cost of erecting steel stacks for office buildings or other buildings of this type, where the stack extends from the ground to the top of the building and is either built into the building or placed on the outside of one of the rear walls, there are several items to be taken into consideration: viz., the length and weight of each section of stack, the facilities for hoisting and placing, and the amount of rigging necessary.

Where each section of the stack weighs 500 to 1,000 pounds, it is customary to place a small gin pole on the roof of the building and lift each section in place.

Three or four iron workers should set up all necessary rigging in one day, ready to place the sections. After the derricks and rigging have been placed ready to start hoisting, the gang should handle, place and bolt one 15 to 20 foot section of stack in 4 hours, or 2 sections (30 to 40 lin. ft), per 8-hour day.

The labor cost placing derricks and erecting a steel stack up to 30" diam. and 30'-0" long should average as follows:

	Hours	Rate	Total	Rate	Total
Ir. wkrs. placing equip...	32	$.....	$.....	$7.10	$227.20
Ir. wkrs. placing stack...	32	.....	.....	7.10	227.20
Labor erecting stack...	64		$.....		$454.40

The labor cost placing derricks and erecting a steel stack up 30" in diam. and 50 to 60 feet long, should average as follows:

	Hours	Rate	Total	Rate	Total
wkrs. placing equip...	32	$.....	$.....	$7.10	$227.20
wkrs. placing stack...	64	.....	.....	7.10	454.40
Labor erecting stack...	96		$.....		$681.60

The labor cost placing derricks and erecting a steel stack up 30" in diam. and 70 to 80 feet long, should average as follows:

	Hours	Rate	Total	Rate	Total
wkrs. placing equip...	32	$.....	$.....	$7.10	$227.20
wkrs. placing stack...	80	.....	.....	7.10	568.00
Labor erecting stack...	112		$.....		$795.20

The labor cost placing derricks and erecting a steel stack up 30" in diam. and 80 to 100 feet long, should average as lows:

	Hours	Rate	Total	Rate	Total
wkrs. placing equip...	32	$.....	$.....	$7.10	$227.20
wkrs. placing stack...	96	.....	.....	7.10	681.60
Labor erecting stack ...	128		$.....		$908.80

To the above costs, add equipment rental, cartage to and from o for equipment, workmen's compensation and liability insurce and erection contractor's overhead and profit.

XTRAS OVER BASE PRICE ON STRUCTURAL SHAPES

Standard Structural I Beams

Size Inches	Extra 100 Lbs.	Size Inches	Extra 100 Lbs.
.....$1.50		10" $0.85	
..... 1.30		12" 31.8 and 35 lbs..... .80	
..... 1.10		12" 40.8 and 50 lbs..... .80	
..... 1.10		15" ..... .80	
..... 1.10		18" ..... .80	
..... 1.00		20" ..... .80	
		24" ..... .80	

Wide Flange Beams

Size Inches	Weight Pounds	Extra 100 Lbs.	Size Inches	Weight Pounds	Extra 100 Lbs.
6".....	8.5	.....$1.70	8".....	13 and 15	.....$1.30
6"	12 and 16	..... 1.60	8".....	17 and 20	..... .45
6".....	15.5	..... .90	8".....	24 to 28	..... .65
8".....	10	.....1.60	8"	31 to 67	..... .90

Wide Flange Beams (Continued)

Size Inches	Weight Pounds	Extra 100 Lbs.	Size Inches	Weight Pounds	Extra 100 Lbs.
10"	11.5	$1.30	16"	58 to 96	$0.40
10"	15 to 19	1.10	18"	45 to 60	.45
10"	21 to 29	.75	18"	64 to 114	.40
10"	33 to 45	.50	21"	55 to 73	.40
10"	49 to 112	.45	21"	82 to 142	.40
12"	14	1.30	24"	68 to 160	.40
12"	16.5 to 22	.90	27"	84 to 177	.40
12"	27 to 36	.60	30"	99 to 132	.40
12"	40 to 58	.45	30"	172 to 210	.45
12"	65 to 190	.45	33"	118 to 152	.45
14"	30 to 38	.50	33"	200 to 240	.50
14"	43 to 53	.45	36"	135 to 194	.45
14"	61 to 136	.40	36"	230 to 300	.50
16"	36 to 50	.50			

H Beams

Size Inches	Weight Pounds	Extra 100 Lbs.	Size Inches	Weight Pounds	Extra 100 Lbs.
4"	13	$1.20	6"	20 and 25	$0.90
5"	18.9	1.00	8"	34.3	.50

Tees

Size Inches	Extra 100 Lbs.	Size Inches	Extra 100 Lbs.
3x2½x$\frac{5}{16}$	$1.70	4x3 x$\frac{3}{8}$	$1.60
3x3 x$\frac{5}{16}$	1.70	4x4 x$\frac{1}{2}$	1.40
3x3 x$\frac{3}{8}$	2.00	5x3 x$\frac{3}{8}$	2.00
4x2½x$\frac{3}{8}$	1.70	4x4½x$\frac{3}{8}$	1.80

Angles

Size Inches	Extra 100 Lbs.	Size Inches	Extra 100 Lbs.
3 x2 x$\frac{3}{16}$	$1.15	4 x4 x$\frac{5}{16}$ to $\frac{3}{4}$	$0.70
3 x2 x$\frac{1}{4}$ to $\frac{1}{2}$	.90	5 x3 x$\frac{1}{4}$	.90
3 x2½x$\frac{1}{4}$ to $\frac{1}{2}$	.85	5 x3 x$\frac{5}{16}$ to $\frac{1}{2}$	.70
3 x3 x$\frac{3}{16}$	.90	5 x3½x$\frac{5}{16}$ to $\frac{3}{4}$	.70
3 x3 x$\frac{1}{4}$ to $\frac{1}{2}$	.80	5 x5 x$\frac{5}{16}$	.90
3½x2½x$\frac{1}{4}$ to $\frac{1}{2}$	.85	5 x5 x$\frac{3}{8}$ to $\frac{3}{4}$	.70
3½x3 x$\frac{1}{4}$ to $\frac{1}{2}$	.80	6 x3½x$\frac{5}{16}$ to $\frac{1}{2}$	.70
3½x3½x$\frac{1}{4}$ to $\frac{1}{2}$	.75	6 x4 x$\frac{5}{16}$	.80
4 x3 x$\frac{1}{4}$	.95	6 x4 x$\frac{3}{8}$ to $\frac{7}{8}$	.65
4 x3 x$\frac{5}{16}$ to $\frac{5}{8}$	.80	6 x6 x$\frac{3}{8}$ to 1	.65
4 x3½x$\frac{1}{4}$	.90	7 x4 all thicknesses	.65
4 x3½x$\frac{5}{16}$ to $\frac{1}{2}$	.75	8 x4 all thicknesses	.65
4 x4 x$\frac{1}{4}$	.85	8 x6 all thicknesses	.50
		8 x8 all thicknesses	.50

Channels—Standard

Size Inches	Extra 100 Lbs.	Size Inches	Extra 100 Lbs.
3"	$1.40	9"	$1.00
4"	1.30	10"	.90
5"	1.20	12"	.80
6"	1.15	13"	.70
7"	1.15	15"	.70
8"	1.10	18"	.70

Stair Stringer Channels

Size Inches	Weight Pounds	Extra 100 Lbs.	Size Inches	Weight Pounds	Extra 100 Lbs.
0"	6.5	$2.25	12"	10.6	$1.95
0"	8.4	1.70			

Zees

Size Inches	Extra 100 Lbs.	Size Inches	Extra 100 Lbs.
1⅛x3 x¼ to ½	$1.10	3¼ x5 x5/16 and ½	$0.95
1/16x4 x¼	1.10	3 7/16x5 1/16x⅜	.95
⅛ x4 1/16x5/16 and ½	1.10	3½ x6 x⅜	.95
5/16x4⅛ x⅜	1.10	3⅝ x6⅛ x½	.95

Approximate Prices of Iron and Steel Products

All prices for structural steel are based on carload shipments om mills, Pittsburgh, Pa., Chicago, Ill., or Birmingham, Ala. reight must be added from nearest mill point to destination.

Prices on steel should always be obtained from mills or earest jobber, as steel prices are subject to frequent change.

	Prices per 100 Pounds Pitts-burgh	Chi-cago	Birm-ingham
tructural shapes	$6.55	$6.55	$6.55
heet piling	7.50	7.50	....
late, carbon steel	6.25	6.25	6.25

stimating the Weight of Wrought Iron, Steel, or Cast Iron

When tables of weights are not handy, the following rules ill prove of value to the estimator when computing the weights wrought iron, steel, or cast iron.

Weight of Wrought Iron.—One cubic foot of wrought iron eighs 480 pounds. One square foot of wrought iron 1-inch ick weighs 40 pounds. One square inch of wrought iron one ot long weighs 3⅓ lbs.

To find the weight of one square foot of flat iron of any

thickness, multiply the thickness in inches by 40, and the resul will be the weight of the iron in pounds.

To find the weight of one lineal foot of wrought iron ba of any size, multiply the cross sectional area in square inche by 3⅓, and the result will be the weight per lineal foot.

Weight of Steel.—One cubic foot of steel weighs 489.(pounds, or 2 percent more than wrought iron. One square foot o steel 1-inch thick weighs 40.8 pounds. A piece of steel 1-incl square and one foot long weighs 3.4 pounds.

To find the weight of one lineal foot of steel bar of any size multiply the cross sectional area in square inches by 3.4, anc the result will be the weight of the steel in pounds. If th weight per lineal foot is known, the exact sectional area ir square inches may be obtained by dividing the weight by 3.4

Weight of Cast Iron.—One cubic foot of cast iron weigh 450 pounds. One square foot of cast iron 1-inch thick weigh 37½ pounds. A piece of cast iron 1-inch square and on foot long weighs 3⅛ pounds. One cubic inch of cast iron weighs .26 pound.

Weights of Square and Round Bars

Thickness or Diameter in Inches	Weight of Square Bar 1 foot long	Weight of Round Bar 1 foot long	Thickness or Diameter in Inches	Weight of Square Bar 1 foot long	Weight o Round Bar 1 foot lon
¼	.213	.167	1 1/16	....	7.60
5/16	.332	.261	¾	10.41	8.18
⅜	.478	.376	13/16	....	8.773
7/16	.651	.511	⅞	11.95	9.39
½	.850	.668	2	13.60	10.68
9/16	1.076	.845	⅛	15.35	12.06
⅝	1.382	1.04	¼	17.21	13.52
11/16	1.607	1.26	⅜	....	15.06
¾	1.913	1.50	½	21.25	16.69
13/16	2.240	1.76	⅝	23.43	18 40
⅞	2.603	2.04	¾	25.71	20.20
15/16	....	2.35	⅞	....	22.07
1	3.400	2.67	3	30.60	24.03
1/16	....	3.01	⅛	....	26.08
⅛	4.303	3.38	¼	35.91	28.21
¼	5.313	4.17	⅜	....	30.42
5/16	....	4.6	½	41.65	32.71
⅜	6.428	5.05	⅝	....	35.09
7/16	....	5.52	¾	47.81	37.55
½	7.650	6.01	4	54.40	42.73
⅝	8.928	7.05			

Weights of Flat Steel Bars

Thickness in Inches	Width of Bars 1"	2"	3"	4"	5"	6"
3/16	.638	1.28	1.91	2.55	3.19	3.83
1/4	.850	1.70	2.55	3.40	4.25	5.10
5/16	1.06	2.12	3.19	4.25	5.31	6.38
3/8	1.28	2.55	3.83	5.10	6.38	7.65
7/16	1.49	2.98	4.46	5.95	7.44	8.95
1/2	1.70	3.40	5.10	6.80	8.50	10.20
9/16	1.92	3.83	5.74	7.65	9.57	11.48
5/8	2.12	4.25	6.38	8.50	10.63	12.75
11/16	2.34	4.67	7.02	9.35	11.69	14.03
3/4	2.55	5.10	7.65	10.20	12.75	15.30
13/16	2.76	5.53	8.29	11.05	13.81	16.58
7/8	2.98	5.95	8.93	11.90	14.87	17.85
15/16	3.19	6.38	9.57	12.75	15.94	19.13
1	3.40	6.80	10.20	13.60	17.00	20.40
1 1/16	3.61	7.22	10.84	14.45	18.06	21.68
1 1/8	3.83	7.65	11.48	15.30	19.13	22.95
1 3/16	4.04	8.08	12.12	16.15	20.19	24.23
1 1/4	4.25	8.50	12.75	17.00	21.25	25.50
1 5/16	4.46	8.93	13.39	17.85	22.32	26.78
1 3/8	4.67	9.35	14.03	18.70	23.38	28.05
1 7/16	4.89	9.78	14.66	19.55	24.44	29.33
1 1/2	5.10	10.20	15.30	20.40	25.50	30.60
1 9/16	5.32	10.63	15.94	21.25	26.57	31.88
1 5/8	5.52	11.05	16.58	22.10	27.63	33.15
1 11/16	5.74	11.47	17.22	22.95	28.69	34.43
1 3/4	5.95	11.90	17.85	23.80	29.75	35.70
1 13/16	6.16	12.33	18.49	24.65	30.81	36.98
1 7/8	6.38	12.75	19.13	25.50	31.87	38.25
1 15/16	6.59	13.18	19.77	26.35	32.94	39.53
2	6.80	13.60	20.40	27.20	34.00	40.80

Weights and Dimensions of Structural I Beams

Size in Inches	Weight Per Ft. Lbs.	Thickness of Web Inches	Width of Flange Inches	Size in Inches	Weight Per Ft. Lbs.	Thickness of Web Inches	Width of Flange Inches
3	5.7	0.170	2.330		14.75	0.494	3.284
	7.5	0.349	2.509	6	12.5	0.230	3.330
4	7.7	0.190	2.660		17.25	0.465	3.565
	9.5	0.326	2.796	7	15.3	0.250	3.660
5	10	0.210	3.000		20	0.450	3.860

Weights and Dimensions Structural I Beams—Contd.

Size in Inches	Weight Per Ft. Lbs.	Thickness of Web Inches	Width of Flange Inches	Size in Inches	Weight Per Ft. Lbs.	Thickness of Web Inches	Width of Flange Inches
8	18.4	0.270	4.000		70	0.711	6.251
	23	0.441	4.171	20	65.4	0.500	6.251
	25.4	0.310	4.660				
	35	0.594	4.944		75.0	0.641	6.391
	31.8	0.350	5.000		85.0	0.653	7.053
	35	0.428	5.078		95.0	0.800	7.200
	40.8	0.460	5.250		79.9	0.500	7.000
	50	0.687	5.477		90.0	0.624	7.124
15	42.9	0.410	5.500		100	0.747	7.247
	50	0.550	5.640		105.9	0.625	7.875
	54.7	0.460	6.000		120	0.798	8.048

Weights of Structural Steel Channels

Depth of Channels, Inches	Weight Per Ft., Pounds	Thickness of Web, Inches	Width of Flange, Inches	Depth of Channels, Inches	Weight Per Ft., Pounds	Thickness of Web, Inches	Width of Flange, Inches
	6.00	0.362	1.602	9	20.00	0.452	2.652
3	5.00	0.264	1.504		15.00	0.288	2.488
	4.10	0.170	1.410		13.40	0.230	2.430
	7.25	0.325	1.725		30.00	0.676	3.036
	5.40	0.180	1.580	10	25.00	0.529	2.889
					20.00	0.382	2.742
5	9.00	0.330	1.890		15.30	0.240	2.600
	6.70	0.190	1.750		30.00	0.513	3.173
	13.00	0.440	2.160	12	25.00	0.390	3.050
6	10.50	0.318	2.038		20.70	0.280	2.940
	8.20	0.200	1.920		50.00	0.720	3.720
7	14.75	0.423	2.303		40.00	0.524	3.524
	12.25	0.318	2.198		33.90	0.400	3.400
	9.80	0.210	2.090	18	58.0	0.700	4.200
8	18.75	0.490	2.530		51.9	0.600	4.100
	13.75	0.307	2.347		45.8	0.500	4.000
	11.50	0.220	2.260		42.7	0.450	3.950

Weights of United States Steel Sheet Piling

Width, Inches	Web Thickness Inches	Weight Per Foot, Pounds
12½	⅜	38
9	¼	16

Weights of Steel Angles—Bar Sizes

Size in Inches	Weight per Ft. Lbs.	Size in Inches	Weight per Ft. Lbs.
½x ½x⅛	.38	2 x2 x⅛	1.65
⅝x ⅝x⅛	.48	3/16	2.44
¾x ¾x⅛	.59	¼	3.19
¾x ¾x3/16	.84	5/16	3.92
⅞x ⅞x⅛	.70	⅜	4.70
x ⅝x⅛	.64	½	6.00
x1 x⅛	.80	2¼x1½x3/16	2.28
3/16	1.16	2¼x2¼x⅛	1.86
¼	1.49	3/16	2.75
⅛x1⅛x⅛	.91	¼	3.62
¼x1¼x⅛	1.01	5/16	4.50
3/16	1.48	2½x1½x3/16	2.44
¼	1.92	¼	3.19
⅛x ⅞x⅛	.91	2½x2 x3/16	2.75
½x1½x⅛	1.23	¼	3.62
3/16	1.80		
¼	2.34	2½x2 x5/16	4.50
5/16	2.86	⅜	5.30
⅜	3.35	½	6.74
¼x1¾x⅛	1.44	2½x2½x⅛	2.08
3/16	2.12	3/16	3.07
¼	2.77	¼	4.10
¼x1¾x5/16	3.39	2½x2½x5/16	5.00
x1¼x3/16	1.96	⅜	5.90
¼	2.55	½	7.70
x1½x⅛	1.44		
3/16	2.12	3 x2 x3/16	3.07
¼	2.77	3 x3 x⅛	2.50
5/16	3.39	3/16	3.71

Weights of Structural Steel Angles

Size in Inches	Weight per Ft. Lbs.	Size in Inches	Weight per Ft. Lbs.	Size in Inches	Weight per Ft. Lbs.
3 x2 x1/4	4.1	4 x3 x5/8	13.6	6 x3 1/2 x3/8	11.7
5/16	5.0	3/4	16.0	7/16	13.5
3/8	5.9	4 x3 1/2 x1/4	6.2	1/2	15.3
3 x2 1/2 x1/4	4.5	5/16	7.7	5/8	18.9
5/16	5.6	3/8	9.1	6 x4 x5/16	10.3
3/8	6.6	7/16	10.6	3/8	12.3
1/2	8.5	1/2	11.9	7/16	14.3
3 x3 x1/4	4.9	4 x4 x1/4	6.6	1/2	16.2
5/16	6.1	5/16	8.2	9/16	18.1
3/8	7.2	3/8	9.8	5/8	20.0
7/16	8.3	7/16	11.3	3/4	23.6
1/2	9.4	1/2	12.8	7/8	27.2
5/8	11.5	5/8	15.7	6 x6 x3/8	14.9
3 1/2 x2 1/2 x1/4	4.9	3/4	18.5	7/16	17.2
5/16	6.1	4 1/2 x3 x3/8	9.1	1/2	19.6
3/8	7.2	5 x3 x5/16	8.2	9/16	21.9
1/2	9.4	3/8	9.8	5/8	24.2
5/8	11.5	7/16	11.3	3/4	28.7
3 1/2 x3 x1/4	5.4	1/2	12.8	7/8	33.1
5/16	6.6	3/4	18.5	1	37.4
3/8	7.9	5 x3 1/2 x5/16	8.7	7 x3 1/2 x3/8	13.0
1/2	10.2	3/8	10.4	7/16	15.0
3 1/2 x3 1/2 x1/4	5.8	7/16	12.0	1/2	17.0
5/16	7.2	1/2	13.6	5/8	21.0
3/8	8.5	5/8	16.8	8 x3 1/2 x1/2	18.7
7/16	9.8	5 x4 x3/8	11.0	8 x6 x1/2	23.0
1/2	11.1	1/2	14.5	3/4	33.8
5/8	13.6	5 x5 x3/8	12.3	8 x8 x1/2	26.4
4 x3 x1/4	5.8	7/16	14.3	5/8	32.7
5/16	7.2	1/2	16.2	3/4	38.9
3/8	8.5	5/8	20.0	7/8	45.0
7/16	9.8	3/4	23.6	1	51.0
1/2	11.1	6 x3 1/2 x5/16	9.8		

Weight of Steel Tees

Pounds Per Lineal Foot

Size Flange by Stem in Inches	Thickness in Inches: 1/8	3/16	1/4	5/16	3/8	1/2
3/4 x 3/4	0.60	....	....	....	....	....
7/8 x 7/8	.73	....	....	....	....	....
1 x1	.90	1.20	....	....	....	....
1 1/4 x1 1/4	....	1.55	1.98	....	....	....
1 1/2 x1 1/2	....	1.88	2.43	....	....	....

Weight of Steel Tees

Size Flange by Stem in inches	Pounds Per Lineal Foot — Thickness in Inches					
	1/8	3/16	1/4	5/16	3/8	1/2
1¾x1¾	....	2.30	2.90	....	....	....
2 x1½	....	....	3.10	....	....	....
2 x2	....	....	3.60	4.40	....	....
2¼x2¼	....	....	4.10	4.90	....	....
2½x2½	....	....	4.60	5.50	6.4	....
2½x2¾	....	....	....	5.9	6.8	....
2½x3	....	....	....	6.1	7.2	....
3 x2½	....	....	....	6.1	7.2	....
3 x3	....	....	....	6.7	7.8	....
3½x3	....	....	....	....	8.5	....
3 x4	....	....	....	....	9.3	....
3 x3½	....	....	....	....	8.5	....
3½x3½	....	....	....	....	9.2	11.7
3½x4	....	....	....	....	9.8	....
4 x2½	....	....	....	....	8.5	....
4 x3	....	....	....	....	9.2	....
4 x4	....	....	....	....	10.5	13.5
4 x5	....	....	....	....	11.9	15.3
4½x2½	....	....	....	....	9.2	....
4½x3	....	....	....	8.6	10.0	....
5 x3	....	....	....	....	11.0	13.6
6½x6½	....	....	....	....	....	19.8

Weights and Dimensions of Standard Z-Bars

Size in Inches Flanges	Web	Thickness	Weight Per Foot	Size in Inches Flanges	Web	Thickness	Weight Per Foot
2 11/16	3	1/4	6.7	3¼	5	5/16	11.6
2¾	3 1/16	5/16	8.5	3 3/16	5 1/16	3/8	14.0
2 11/16	3	3/8	9.8	3¼	5	½	17.9
3 1/16	4	1/4	8.2	3½	6	3/8	15.7
3⅛	4 1/16	5/16	10.3	3⅝	6⅛	½	21.1
3 3/16	4⅛	3/8	12.5				

Weights of Standard Diamond Steel Floor Plates

Thickness Inches	Weight Per Sq. Ft. Pounds	Thickness Inches	Weight Per Sq. Ft. Pounds
1/8	8.00	5/16	13.75
3/16	8.75	3/8	16.25
1/4	11.25	½	21.5

Weights of Steel H-Columns

Size in Inches	Weight Per Ft., Pounds	Size in Inches	Weight Per Ft., Pounds
4x4	13.8	6x6	25.0
5x5	18.9	6x6	27.5
6x6	20.0	8x8	32.6
6x6	22.5	8x8	34.3

Weights of Round Head Structural Rivets

Diam. and Length Inches	Weight per 100 Rivets Lbs.	Diam. and Length Inches	Weight per 100 Rivets Lbs.	Diam. and Length Inches	Weight per 100 Rivets Lbs.	Diam. and Length Inches	Weight per 100 Rivets Lbs.
½x1	9.49	⅝x4½	46.76	¾x6	87.61	⅞x6	122.54
1½	12.24	5	51.10	6½	93.80	6½	130.97
2	14.99	5½	55.45	7	99.97	7	139.40
2½	17.74	6	59.80	7½	106.15	7½	147.83
3	20.49	¾x1	25.81	8	112.33	8	156.26
3½	23.24	1½	31.99	⅞x1½	46.67	1 x2½	86.82
4	25.99	2	38.17	2	55.10	3	97.80
⅝x1	16.38	2½	44.35	2½	63.53	3½	108.79
1½	20.68	3	50.53	3	71.96	4	119.77
2	24.98	3½	56.71	3½	80.39	4½	130.76
2½	29.28	4	62.89	4	88.82	5	141.74
3	33.58	4½	69.07	4½	97.25	5½	152.73
3½	37.88	5	75.25	5	105.68	6	163.71
4	42.18	¾x5½	82.05	5½	114.11		

Weights of Steel Plates in Pounds Per Square Foot

Thickness	Steel Estimating	Thickness	Steel Estimating
3/16	7.65	¾	30.60
¼	10.20	⅞	35.70
5/16	12.75	1	40.80
⅜	15.30	1¼	51.00
7/16	17.85	1½	61.20
½	20.40	1¾	71.40
⅝	25.50	2	81.60

Weight of Corrugated Sheets in Pounds Per 100 Square Feet

Gauge Nos.	Black and Painted: 2, 2½ and 3-Inch Corrug.	Black and Painted: 1¼-Inch Corrug.	Galvanized: 2, 2½ and 3-Inch Corrug.	Galvanized: 1¼-Inch Corrug.
16	271	...	286	...
18	217	...	232	...
20	163	170	178	185
22	136	142	151	157
24	110	114	125	129
26	83	86	98	101
27	76	79	91	94
28	68	72	85	87

STEEL JOISTS

Standard and longspan steel joists were developed primarily to take the place of wood construction. In recent years the Underwriters' and Building Departments have recognized the merits of this construction from the point of fire resistive and structural qualities with the result that this type of floor and roof construction has not only replaced wood to a great extent but other types of fire resistive floor construction to an equal extent. Steel joist construction is recognized and accepted by all building codes.

Typical Shortspan Steel Joist

Standard open web and longspan steel joists are manufactured by welding chord members made up of hot rolled structural or cold formed sections to round bar or angle web members to form a Warren truss. Information on the various types of steel joists can be obtained from the latest catalogs published by the Steel Joist Institute and the joist manufacturers.

When steel joists are used in fireproof construction, it is necessary to place a 2″ to 2½″ reinforced concrete slab over the joists, and a fire resistant ceiling of gypsum board or plaster beneath the joists to obtain the required fire rating.

Where a wood floor is required, wooden nailing screeds supported on screed clips are embedded in the concrete slab and the wood flooring is then nailed to the screeds.

Steel joists may also be used in semi-fireproof construction by nailing the wood sheathing directly to nailers attached to the joists without the use of a protective concrete slab. Some manufacturers of steel joists have met the demand for this type of construction by fabricating a nailer joist with the wood nailer attached in the shops by the use of lag screws or bolts.

Open web joists may be used to great advantage in all types of light occupancy buildings. The open web construction greatly facilitates the placing of plumbing, conduits, etc., making unnecessary the need of a furred ceiling or heavy fills on top of the structural slab.

Steel joists are also used in industrial construction to replace structural steel roof purlins with a resulting economy of materials. Metal roof deck is then usually welded to the joists and light weight insulating material either poured or rigid board is applied or glued to the metal deck and the roofing is installed.

Estimating Steel Joists.– Steel joists and related products are generally sold by the manufacturer directly to the contractor. When preparing general contract estimates the most satisfactory method is to send plans or sketches to the manufacturer or his agent thus assuring a subbid based on an economical layout and design and one which includes the necessary accessories such as lath, clips, ceiling extension rods, bridging, etc.

In his quotation the manufacturer will note the tonnage of joists which will enable the contractor to figure the necessary cartage and labor of erection. The cost of joist erection including placing of accessories varies from $40.00 to $70.00 per ton depending on labor conditions, location and type of building.

Labor Setting Steel Joists.—The labor cost of handling and setting steel joists is usually estimated by the ton, based on the total weight of the joists to be placed.

This cost will vary considerably, depending upon the type of building, size of joists, length of spans, amount of handling and hoisting necessary, etc.

It is much cheaper to set joists on long straight spans and large floor areas, such as garage and factory buildings, office buildings, etc., than on residences and other irregularly constructed buildings.

All steel joists must be bridged and connected according to the Steel Joist Institute standards.

On an ordinary job of steel floor joists of regular construction and fairly long spans, two men working together should handle and place 3,500 to 4,500 lbs. of joists (including bridging), per 8-hr. day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Ironworker	8	$.....	$.....	$7.10	$56.80

On jobs of irregular construction, such as schools, hospitals, apartment buildings, residences, etc., two men working together should handle and place 2,400 to 2,800 lbs. of joists (including bridging), per 8-hr. day, at the following labor cost per ton:

	Hours	Rate	Total	Rate	Total
Ironworker	12.3	$.....	$.....	$7.10	$87.33

Placing Metal Deck on Top of Steel Joists.—When metal deck is placed over the top of steel joists to receive the concrete slab or lightweight insulating materials, the metal deck is usually spot welded to the joists.

On work of this type two men working together should place and weld 150 to 170 sq. ft. of deck per hour at the following labor cost per square of 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Iron worker	1.2	$.....	$.....	$7.10	$8.52
Cost per sq. ft.					.085

In many installations acoustical tile ceilings are attached to the underside of or suspended from steel joists. There are on the market today acoustical tile ceiling systems, which have Underwriters Laboratories fire ratings. Acoustical ceilings as well as metal lath and plaster ceilings may be attached directly to the joist or may be suspended below them at any elevation desired.

Placing Metal Lath Ceilings Under Steel Joists.—Metal lath is fastened to the steel ceiling joists by wire clips, made for this purpose.

A lather should place and fasten 65 to 75 sq. ft. of ceiling lath an hr. at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Lather	1.5	$.....	$.....	$6.50	$9.75
Cost per sq. ft.					.098

Prices of Steel Joists.—Costs of standard steel joists will vary with several factors among which are the size of the job, the number of joists of one particular size and length, and the location of the job. For an average job the cost of standard joists will be in

the range of $270.00 to $300.00 per ton, which would include nominal bridging members and other accessories.

Costs of longspan steel joists will vary with the same factors as given above for standard joists. For an average job the cost of the longspan joists will range from $280.00 to $330.00 per ton including accessories.

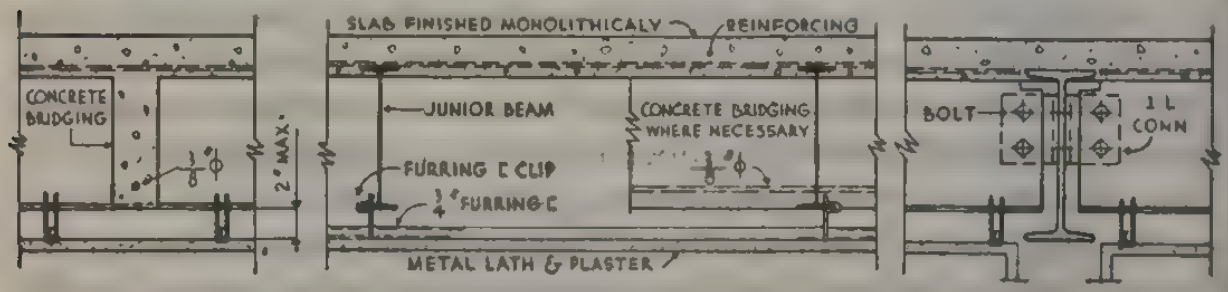
JUNIOR STEEL BEAMS*

Junior beams are lightweight hot rolled structural I-beams which are used as secondary floor and roof beams in residences, schools, stores, apartments, hospitals and all types of light occupancy buildings. They are well adapted for purlins in mill buildings.

They are rolled from copper-bearing billets to ASTM A7-42 specifications, and are made in 6", 7", 8", 9", 10", 11" and 12" sizes.

Sizes and properties are given below:

Depth in Inches	Wt. per Ft. Lbs.	Web Thick. Inches	Flange Wdth. Inches	Area Inches
6	4.4	.114	1.84	1.30
7	5.5	.126	2.08	1.61
8	6.5	.135	2.28	1.92
10	9.0	.155	2.69	2.64
12	11.8	.175	3.06	3.45



Monolithically Finished Concrete Floor in Conjunction with Junior Beams.

Junior steel beams are usually sold to the contractor by a fabricator or warehouse. The average warehouse price for plain unpainted beams cut-to-length is 12 to 15 cents per pound.

The cost of cutting, punching holes, and coping junior beams will run approximately as given below although when much fabricating is required it is advisable to refer plans to a local fabricator or warehouse for a subbid.

*Jones & Laughlin Steel Co.

Top cope, per end	$1.75
Bottom cope and seat angles, per end	5.10
Cutting end on diagonal, per end	2.25
Anchor holes in web, per hole	.40
Conduit holes in web, per hole	.40

Junior steel beams can be used in conjunction with monolithically finished concrete floors; with a concrete floor slab and a wood finish floor, or precast gypsum slabs may be laid over the top flange of the junior beams.

By encasing the top flanges in concrete, the floor is made rigid and does not require bridging in light occupancy buildings.

Where the slab is poured on metal lath or where gypsum plank is used, adjustable steel rigid bridging is furnished.

When a poured-in-place concrete floor is used, the forms are easily constructed by cutting short pieces of lumber to rest on the lower flanges of the beams, which in turn support the floor sheathing, as shown in the accompanying illustration.

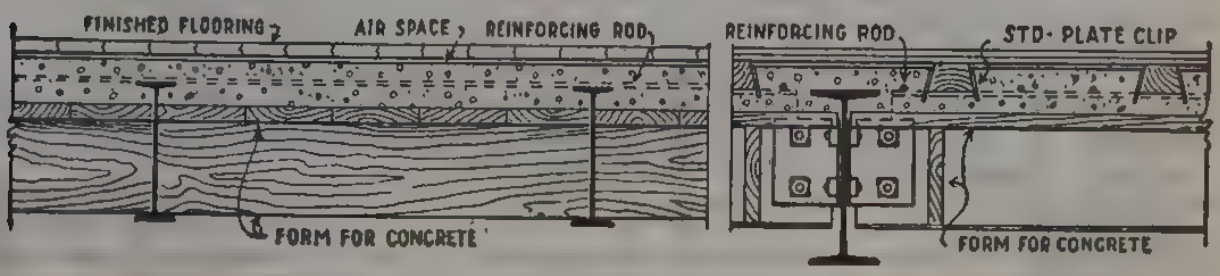
The reinforcement of the concrete slab usually consists of welded wire fabric, the size and spacing of the wire depending upon the span of the slabs and the loads to be carried.

Special plate clips are furnished for attaching the wood floor screeds to the top of the beams. Furring channel clips varying in depth from ¾″ to 2″ are furnished for attaching furring channels to the bottom flange of the junior beams.

Where joists rest on walls or bearing partitions, beam anchors are provided. Where the tops of junior beams are flush with tops of supporting beams either clip angles as illustrated or shelf angles are provided. Where the tops of the beams are 2½″ above the tops of supporting beams, part of the beam is blocked out and an angle seat is welded to the junior beam which rests on the top flange of the supporting beam.

For house construction practically no fabrication is required.

Warehouses carry the beams in stock lengths from which they furnish the necessary cut lengths to meet job requirements.



Illustrating Method of Constructing Wood Forms for Concrete Floors Supported by Junior Beams.

Table of Junior Beam Spacings for Various Live Loads

Span	20 Lb. L. L.		30 Lb. L. L.		40 Lb. L. L.		50 Lb. L. L.		60 Lb. L. L.	
	Size ins.	Space ins.	Size ins.	Space ins.	Size ins.	Space ins.	Size ins.	Space ins.	Size ins.	Space ins.
12'-0"	6	31	6	31	—	—	—	—	—	—
	7	46	7	46	7	39	7	31	7	31
	8	46	8	46	8	46	8	46	8	39
	9	46	9	46	9	46	9	46	9	46
13'-0"	6	31	—	—	—	—	—	—	—	—
	7	39	7	39	7	31	7	31	8	31
	8	46	8	46	8	46	8	39	9	46
	9	46	9	46	9	46	9	46	10	46
14'-0"	7	39	7	31	8	39	8	31	8	31
	8	46	8	46	9	46	9	39	9	39
	9	46	9	46	10	46	10	46	10	46
15'-0"	7	31	8	39	8	31	8	31	9	31
	8	46	9	46	9	39	9	39	10	46
	9	46	10	46	10	46	10	46	11	46
16'-0"	8	39	8	31	8	31	9	31	9	31
	9	46	9	39	9	39	10	46	10	39
	10	46	10	46	10	46	11	46	11	46
17'-0"	8	31	8	31	9	31	9	31	10	31
	9	39	9	39	10	46	10	39	11	46
	10	46	10	46	11	46	11	46	12	46
18'-0"	8	31	9	31	9	31	10	31	10	31
	9	39	10	46	10	39	11	46	11	39
	10	46	11	46	11	46	12	46	12	46
19'-0"	9	31	9	31	10	31	10	31	11	31
	10	46	10	39	11	46	11	39	12	46
	11	46	11	46	12	46	12	46	—	—
20'-0"	9	31	10	31	10	31	11	31	11	31
	10	39	11	46	11	39	12	46	12	39
	11	46	12	46	12	46	—	—	—	—
21'-0"	10	39	10	31	11	31	11	31	12	31
	11	46	11	39	12	46	12	39	—	—
	12	46	12	46	—	—	—	—	—	—
22'-0"	11	39	11	39	11	31	11	31	12	31
	12	46	12	46	12	39	12	39	—	—
23'-0"	11	39	11	31	11	31	12	31	12	31
	12	46	12	39	12	39	—	—	—	—
24'-0"	12	39	12	39	12	31	12	31	12	29

NOTE:—When spacings are greater than 39", sleepers should be 2" x 4" laid flat, instead of the usual 2" x 3" beveled sleepers.

Forms for Concrete Floors.—The cost of wood forms and the labor cost of placing concrete will run substantially the same as given on the previous pages under "Precast Concrete Joists."

Labor Handling and Placing Junior Beams.—The labor cost of handling and placing junior beams, placing metal lath, etc., is about the same as given for steel joists.

Carrying Capacity of Junior Beams

The table giving sizes and spacing of junior beams for various floor loads is based on a dead load of 45 lbs. per sq. ft. made up as follows:

	Lbs. per Sq. Ft.
Finished flooring	4 lbs.
Concrete	30 lbs.
Junior beams	3 lbs.
Plaster ceiling	8 lbs.
Total dead load per sq. ft.	45 lbs.

STEEL ROOF DECK

Steel roof deck is formed from copper or non-copper bearing steel sheets or strip steel in 18, 20 or 22 gage. Most commercial decks have a standardized cross section with longitudinal ribs spaced 6" on centers. Sections are 6", 12", 18" or 24" in width and are manufactured in various lengths to suit job conditions, usually in the 14-ft. to 31-ft. range, although some can be supplied in greater lengths.

Deck sections are usually 1½" deep, but some manufacturers supply a 1¾", 2" or 2½" deep deck. Sections have interlocking or nesting side laps and telescoping or nesting end laps.

Under ordinary roof live loads—30 to 40 lbs. per sq. ft.—20 gauge deck is normally used for spans from 6'-0" to 7'-6" centers of purlins and 18 gage deck for spans from 7'-0" to 8'-6". Specific information on allowable loads can be obtained from the various manufacturers. By extending a single sheet over two or more purlin spaces, structural continuity, increasing load carrying capacity, can be obtained. Dead load of deck, insulation and built-up roofing is approximately 7 lbs. per sq. ft.

Approximate cost of steel roof deck, delivered to job site in the eastern or northern states, on an average size carload lot job (20,000 sq. ft. or more) is as follows:

Gauge of Roof Deck	Price per Sq. Ft. 1½" Deck
22 Ga.	$0.27
20 Ga.	0.31
18 Ga.	0.35

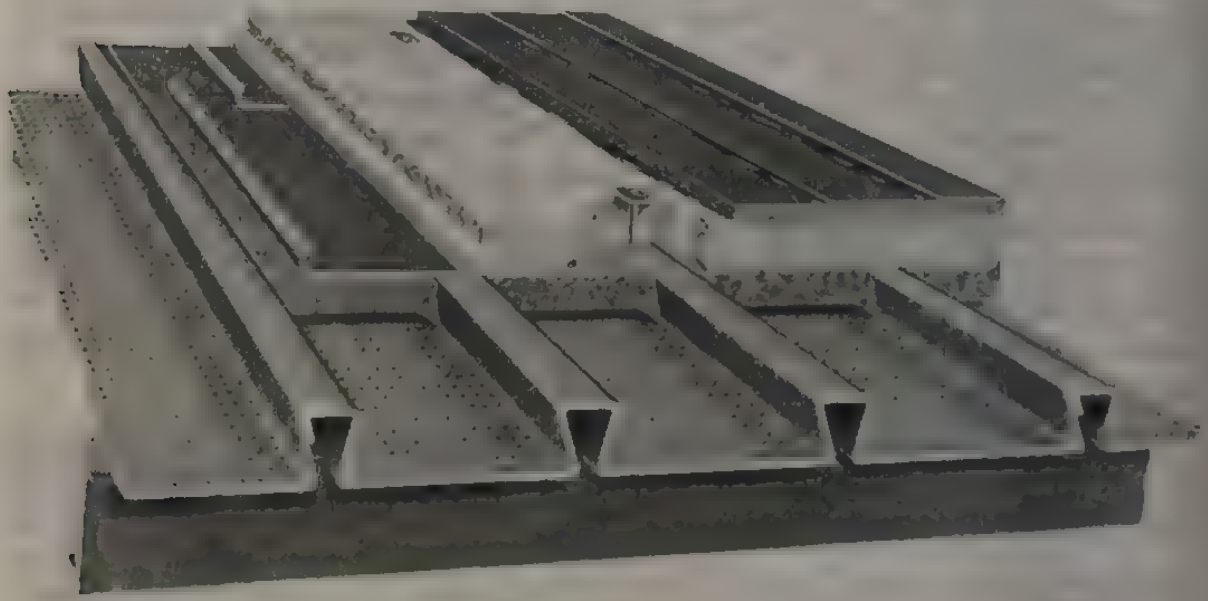
Erection of Steel Roof Deck.—Steel roof deck can be erected in almost any kind of weather, permitting other trades to work under cover much more rapidly. Deck must be welded to steel purlins. Two tack welds per 18" width of deck section at end laps and one weld on the outside rib on intermediate supports are recommended.

With single deck sections covering 30 to 40 sq. ft., a well organized crew can erect 5,000 sq. ft. per day under favorable conditions, but a fair average for estimating purposes would be about 2,500 sq. ft. per 8-hr. day.

A deck erection crew generally consists of 5 or 6 men. Two men are required to hoist the deck sections to the roof, two men receive deck on roof and place it and a welder completes the crew—sometimes an assistant to the welder is added. Labor costs per square (100 sq. ft.) on recent construction averaged 2.75 times the hourly labor rate for workers employed to handle erection, which includes the job overhead cost.

Acoustic Steel Roof Deck

Holorib*, 1½" depth, steel roof deck, perforated with holes approximately ⅛" in diameter and staggered 25/64" on centers in the flat portion of the deck between ribs, is used as an element of a sound control unit providing an acoustically treated ceiling and support for insulation and built-up roofing.



Acoustical Steel Roof Deck.

*Fenestra Incorporated, Chicago, Ill.

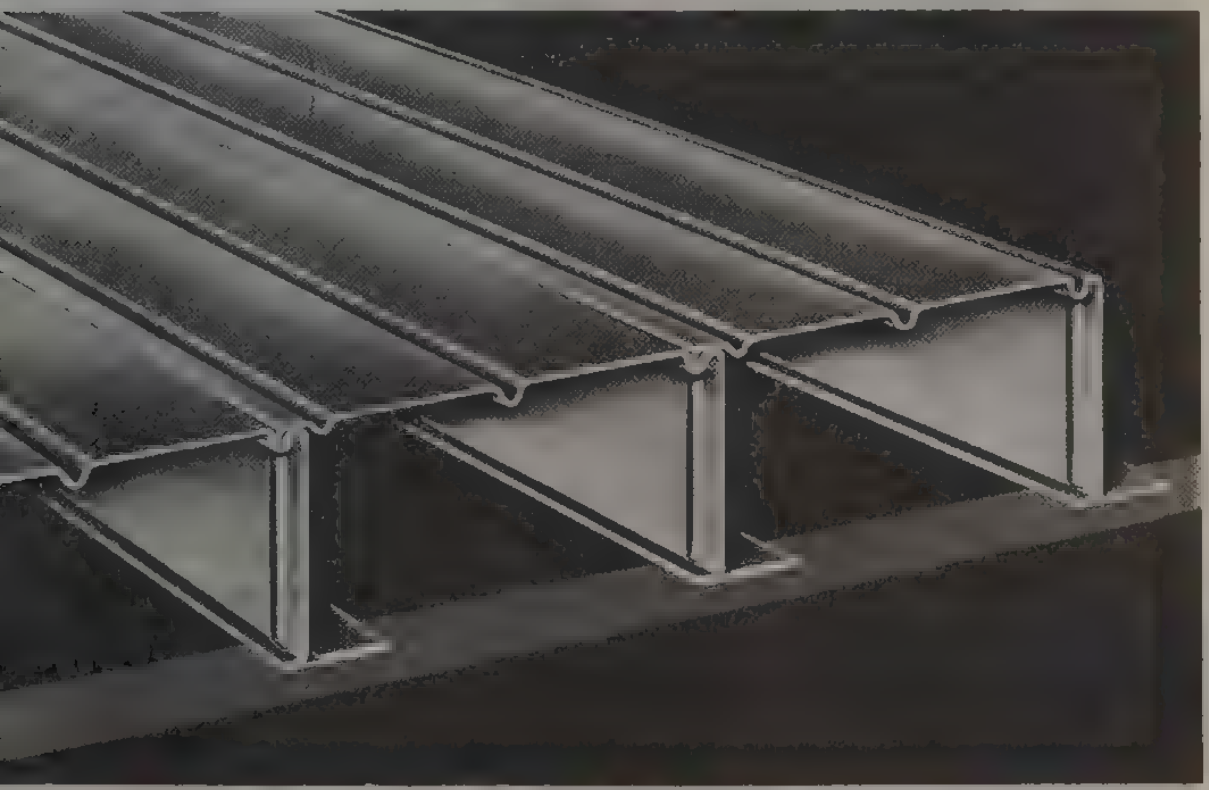
Acoustic Holorib is erected with the flat side down acting as the exposed ceiling. A 1-lb. density glass fiber arched pad is placed between the ribs. It provides a noise reduction coefficient of 0.80 and metal faced ceiling can be washed or painted without impairing acoustical efficiency.

Acoustic deck is installed by welding, similar to ordinary deck installation and on an average job, a crew should erect 2,200 to 2,300 sq. ft. of deck per 8-hr. day.

The 18-ga. acoustical steel deck is used for purlin spacings of not more than 10′-6″ and its cost, complete with fiber glass acoustical insulation, is about $0.78 per sq. ft., delivered to job sites in the eastern or northern states.

Longspan Deck

Longspan deck is formed from a single 14, 16, 18 or 20 gauge steel sheet into 4½″, 6″ or 7½″ deep pans 12″ wide. These are rolled sections with integral stiffening ribs formed into the top flange. Interlocking longitudinal side laps are provided on opposite edges for positive side lap attachment and are fastened by welding. Maximum spans allowable vary from 20′-0″ to 32′-0″.



Longspan Roof Deck

Longspan deck is easily erected—on an average job, a crew should erect 2,200 to 2,400 sq. ft. per 8-hr. day.

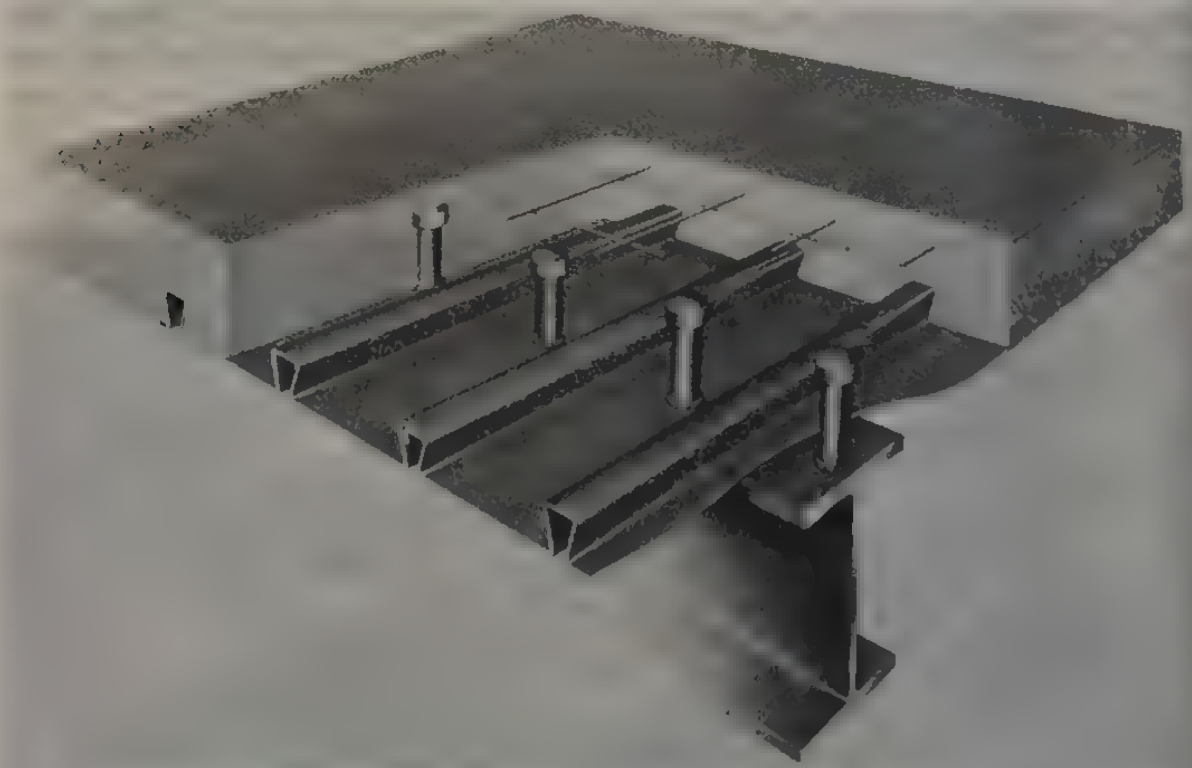
Approximate cost of longspan steel roof deck, delivered to job

sites in the eastern or northern states, is $0.90 to $1.10 per sq. ft., depending upon gauge and length of sections.

Reinforcing Floor Forms

Holorib* steel deck, erected in an inverted position (with ribs up) can be used as a reinforcing form for concrete construction. It acts as a form to support the concrete and permits the ribs to act as reinforcing.

Holorib reinforcing forms can be erected for an entire structure as soon as the steel framework is placed, providing an immediate working platform and protective staging for all trades. Concrete can be placed at any portion of the building without regard for removing, cleaning and re-setting temporary formwork. Holorib forms usually provide all necessary rein-



Concrete Slab With Steel Forms Used In Conjunction With Composite Beam Design

forcing to satisfy flexure requirements—the only additional reinforcing ordinarily required is temperature mesh to minimize shrinkage cracking. Tight form joints prevent concrete from dripping to lower floors, saving clean-up time.

Holorib reinforcing forms can also be used in conjunction with composite beam design. Ample area for concrete around stud

*Fenestra Incorporated, Chicago, Ill.

ALLOWABLE LOAD CARRYING CAPACITY

Sand and Gravel Concrete—3000 psi strength

Span ft.	Slab in.	16	18	20	22
		Simple, double or cont.			
5	2½	314	314	314	223
	3	398	398	398	281
6	2½	262	262	262	186
	3	331	331	331	234
	3½	401	401	401	283
7	2½	219	210	•191	159
	3	284	284	284	200
	3½	345	345	345	242
	4	405	405	394	284
	4½	466	466	410	326
8	2½	167	•153	•128	108
	3	247	235	180	138
	3½	301	301	252	168
	4	354	354	304	198
	4½	408	408	351	229
	5	461	461	399	260
9	2½	•122	•108	87	83
	3	•192	148	135	118
	3½	267	210	190	144
	4	315	265	252	171
	4½	362	306	306	197
	5	375	348	348	224
	5½	390	390	390	251
10	2½	107	71	64	61
	3	158	113	102	96
	3½	173	162	145	126
	4	232	217	195	149
	4½	270	270	250	172
	5	307	307	307	195
	5½	344	344	344	219
	6	381	381	381	242
	6½	418	418	418	266
11	2½	88	53	48	45
	3	93	87	77	73
	3½	135	126	113	106
	4	183	170	152	131
	4½	237	220	196	151
	5	273	273	245	172
	5½	306	306	278	193
	6	339	339	308	214
	6½	373	373	338	235
	7	407	407	368	256
12	2½	43	40	35	33
	3	72	67	59	55
	3½	106	99	87	82
	4	146	135	120	112
	4½	190	176	156	134
	5	238	220	196	152
	5½	275	269	223	171
	6	305	305	247	189
	6½	335	335	271	208
	7	365	365	296	227

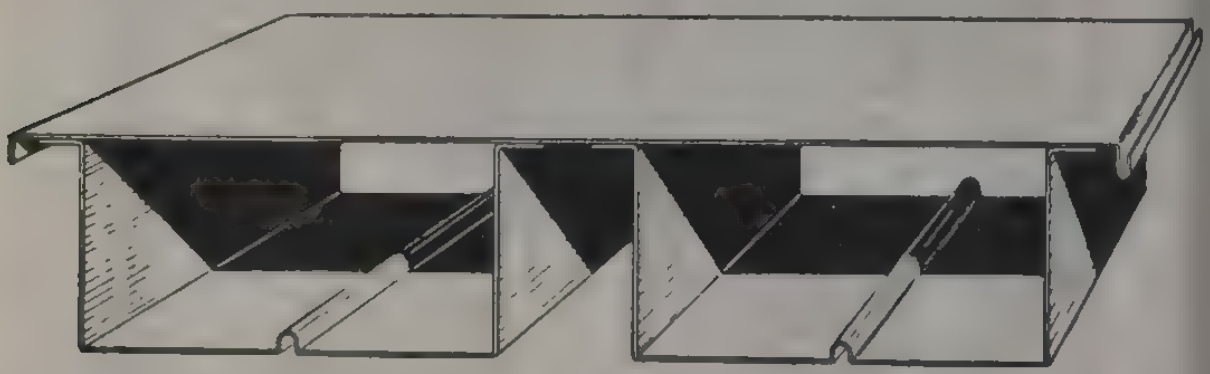
shear connectors and between deck ribs permits full effectiveness of the connectors. Standard A.I.S.C. Composite Design Procedure may be followed using the total slab depth in beam property calculations.

Where a plastered ceiling is not required, the smooth steel surface of the form provides an attractive ceiling. The small openings at the bottom of ribs provide dovetail slots for reception of fixture hangers. This eliminates placing of inserts or drilling holes in the slab.

Reinforcing floor forms are installed by welding, same as ordinary steel roof deck, and costs of material and erection are practically the same as given for Steel Roof Deck.

CELLULAR STEEL DECK AND FLOOR PANELS

Light gauge cellular steel structural panels are used for long-span structural floors and roofs. Some panels are composed of two identically formed beam sections and a flat plate—others are formed from two ribbed sections and a flat plate. All panels have interlocking side joints. Components are factory assembled by spot welding. Panels are manufactured in gauges from 20 to 13 and are normally available in 24" widths—some panels are fabricated in 12" widths. Lengths are available up to 40'-0", while depths vary from 1½" to 7½".



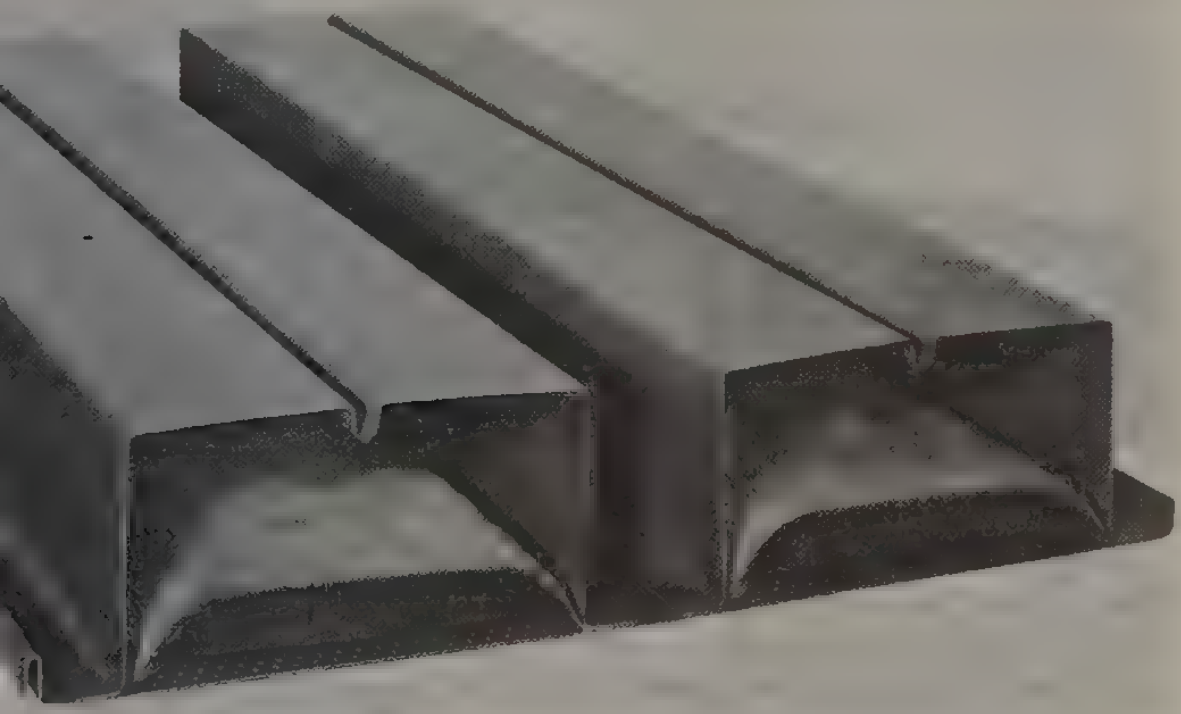
Cellular Steel Deck and Floor Panel

This type of panel is easily handled and erected, as it is deck and joist combined. Concrete floor forms are eliminated and panels provide a working platform for other trades.

A flat, plate down, installation is often used to provide an attractive ceiling which needs only a finish coat of paint to complete the job. Voids between beam sections may be filled and covered with 2½" of concrete for floors or covered with rigid board insulation and built-up roofing for roofs. Installations with beam section forming the ceiling can be merely painted to give a finished fluted ceiling or a suspended ceiling can be erected to provide a flush type ceiling.

Where panels are covered with a concrete fill, the use of temerature mesh, to reduce shrinkage cracks, is recommended.

The cost of cellular panels, delivered to job site, ranges from 1.25 to $1.75 per sq. ft., depending upon size of panels and load nd span conditions. On a typical multiple story building, inolving spans of 8′-0″ to 10′-0″, the installed cost for 3″ deep ellular panels would be about $1.20 to $1.50 per sq. ft.



Acoustically Treated Deck and Floor Panel

Erecting Cellular Steel Floor and Roof Panels.—The labor ost of erecting cellular steel floor and roof panels varies from 0.15 to $0.25 per sq. ft., depending upon the difficulty of the job. Under favorable conditions, a well organized crew can place up o 1,500 sq. ft of panels in an 8-hr. day, but for the average job, ,100 to 1,200 sq. ft. would be a good day's work for the crew.

INSULATED METAL WALL PANELS

Insulated steel, aluminum, and aluminum-steel wall panels vere developed to provide the answer to dry wall construction, nabling the builder to enclose large areas in a minimum of time. They are designed to serve as exterior walls and partitions.

One typical wall panel consists of two members pressed together at the side laps to form a structural unit. This type has a strip of felt inserted the full length of the joint to prevent metal-to-metal contact between the two members. These panels

are factory filled with borosilicate glass fiber insulation, 2½-lb. density. An end closure is attached to both ends of the panel to insure the proper retention of insulation and to seal the panels. Panels are manufactured in standard widths of 12", 16", 24" or 32" and thicknesses vary from 1 9/16" to 3⅜", depending upon whether surfaces are flat or fluted and thickness of insulation used.

Insulated Metal Wall Panel

Lengths also vary from 6'-0" to 30'-0". Maximum allowable clear span for an all galvanized steel panel, based on a wind load of 20 lbs. per sq. ft., is 14'-0"; for an all aluminum panel, 10'-6" and for an aluminum-galvanized steel panel, 12'-0".

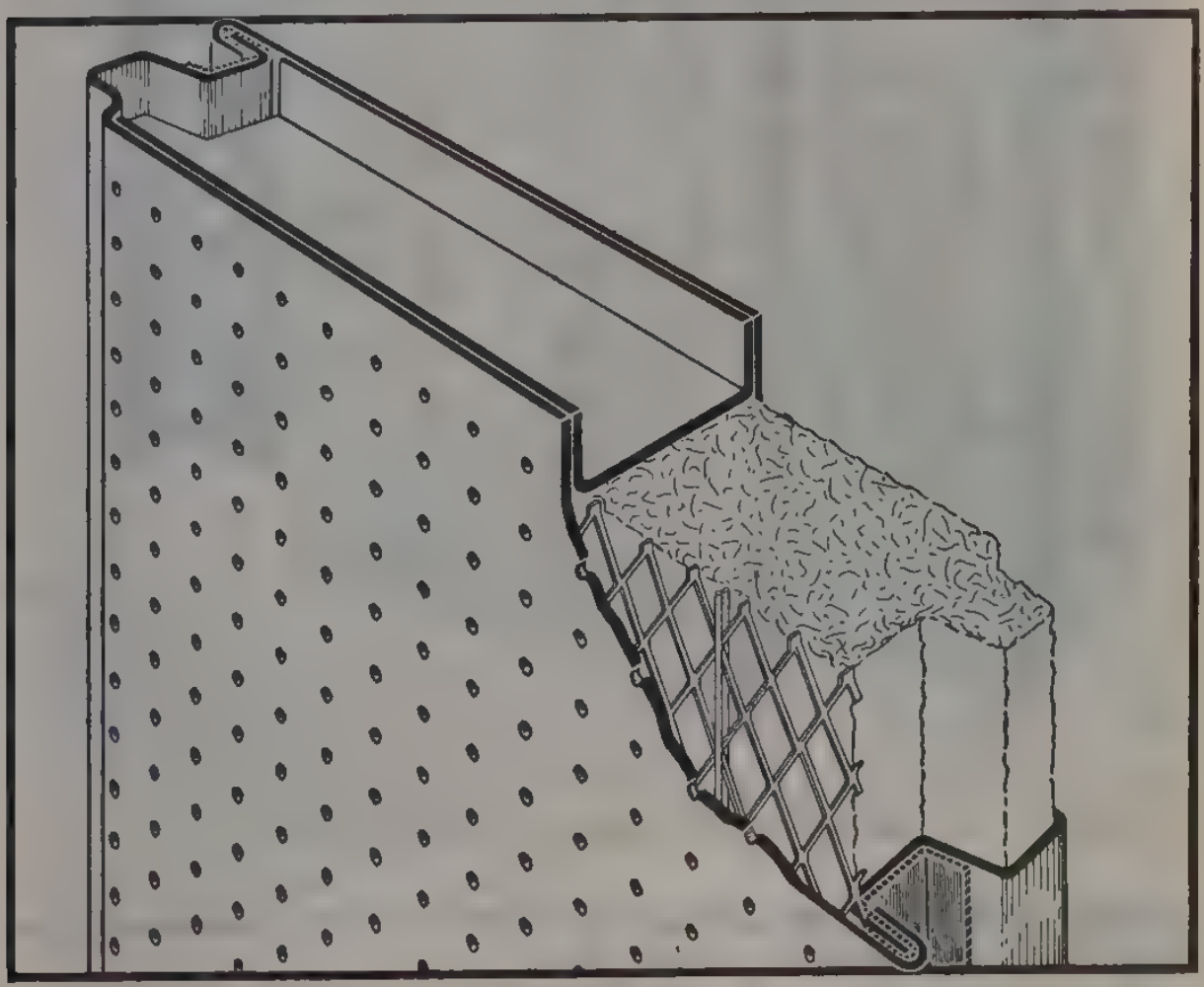
The interlocking tongue and groove between adjacent panels offers a joint that unites the series of units into a continuous wall surface. When using the interlocking tongue and groove connection the panels may be erected either vertically or horizontally in walls and partitions. Also, this double acting tongue and groove joint, has three positive bearing surfaces which permit a series of panels to act as a structural unit in resisting loads from either side of a wall. With panels in the horizontal position, the double tongue and groove joint forms a shiplap construction, adding to the weather-resisting properties of the complete wall unit. Where panels are used as semi-permanent constructions enclosing the face of a building to which a future extension is contemplated, details can allow for 100 percent salvaging of the panels.

Steel Wall Panels.—Steel type panels are manufactured of 18, 20 or 22 gauge sheet steel, with either a baked-on coat of shop primer or galvanized finish. The all-steel panel has the advantage of high structural strength and low initial cost. The panels are caulked during erection by buttering a mastic in the female

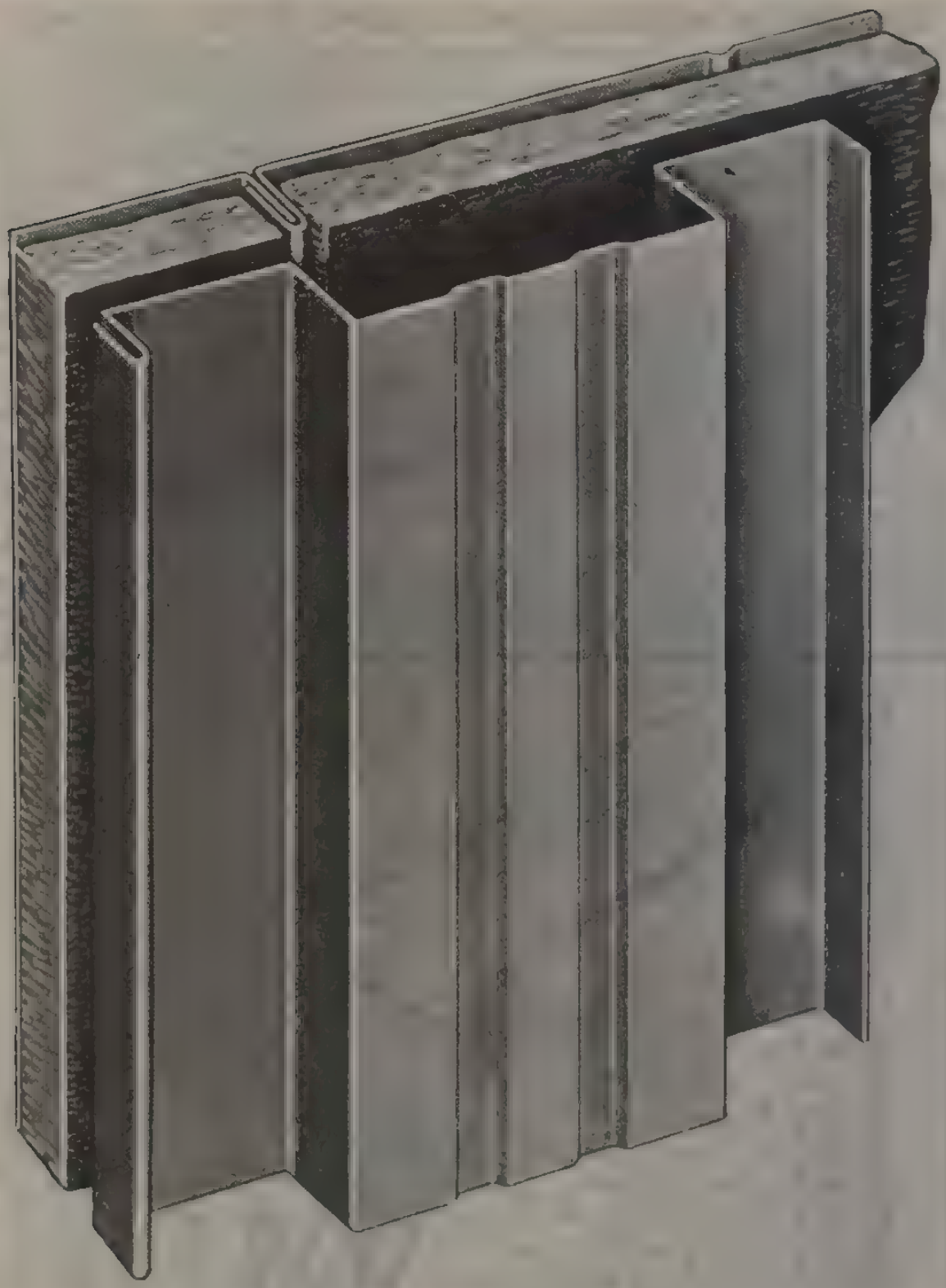
joints prior to putting the panels in place. Welding of panels to supporting steel is the most common method of attachment. The material cost of shop assembled steel wall panels is approximately $1.70 per sq. ft.

Aluminum Wall Panels.—The extreme light weight of the long length aluminum panels allows easier and faster handling and erecting in the field. A typical aluminum panel, 12′-0″ long, 24″ wide weighs only 60 lbs. The erection procedure is the same as for steel panels except that direct contact between the aluminum and steel must be prevented. A coating of bituminous paint is recommended for this purpose. Maintenance costs become negligible with an all-aluminum construction. The original mill finish will eventually darken with weathering. Bolting of panels to supporting steel and use of pre-formed sections are the most common methods of attachments. Aluminum wall panels cost about $2.25 per sq. ft.

Aluminum-Steel Wall Panels.—To supply the need for an economical panel which would have an aluminum exterior surface for high resistance to corrosion and weather, but did not



Acoustically Treated Wall Panel



Field Assembled Insulated Metal Wall Panel

require this type surface on the interior, the aluminum-steel panel was developed.

For particular use in conjunction with aluminum-steel panels

and all aluminum panels, extrusions have been developed which enable the panel to be placed in position and held through the clamping action of the extrusion at the base of the panel. These extrusions eliminate bolting and accelerate erection. They also provide 100 percent salvagability of the panel walls when placed in buildings which are to be expanded later. At the head of the panels there is usually no extrusion, but rather a toggle bolt is used to fasten at this position. The material cost of aluminum-steel wall panels is about $2.10 per sq. ft.

Labor Erecting Metal Wall Panels.—A normal wall panel job with panel lengths ranging between 6 and 8 ft. should be constructed at the rate of 12 manhours per 100 sq. ft., which includes handling all work from unloading to actual fastening of the panels in place. A difficult job, involving the use of toggle bolts, aluminum panels, short runs, either long or short panels, will take somewhat longer—up to 20 manhours per 100 sq. ft. A typical crew would consists of one man to caulk and hoist, a man to receive and distribute the panel, a man to place and weld the bottom, one to plumb and weld the top, also a man to do the cutting, attach closures, place flashings, bitumastic, etc. The erection costs for a normal job are about $0.60 per sq. ft. and $0.85 per sq. ft. for a difficult job. The erection figures include normal percentages of taxes, field expense, insurance, overhead and profit.

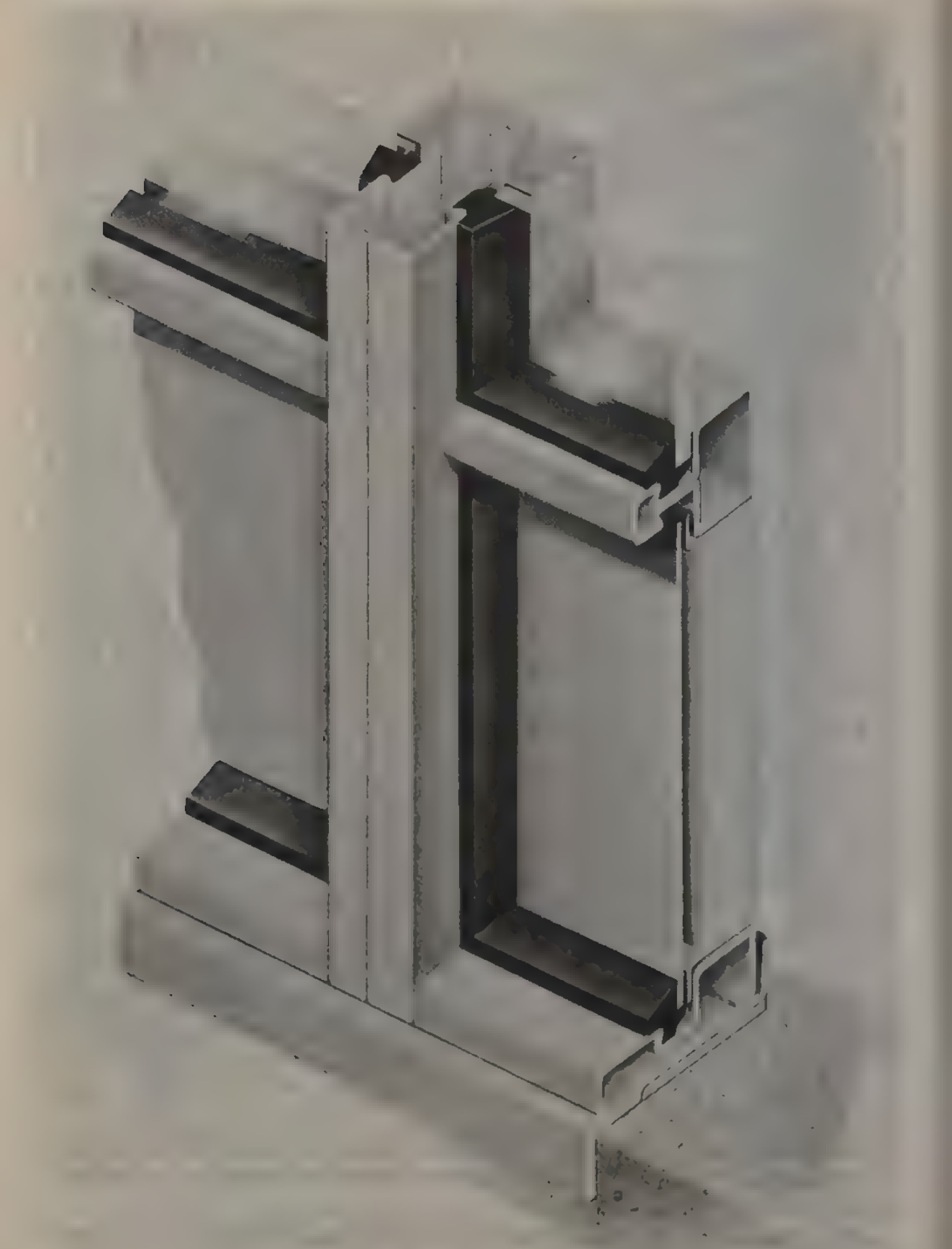
Field Assembled Wall Panels.—Steel, aluminum and combination aluminum-steel wall panels are also available for field assembly—to be assembled and erected simultaneously. Manufactured with a deeply fluted or ribbed exterior surface, they are particularly suited to modern architectural designs.

Panel lengths generally range from 6′-0″ to 40′-0″—some are available up to 60′-0″. Widths are 12″, 18″ and 24″ and depth varies from 3″ to 3½″.

Steel panels—prime coat, galvanized or stainless—are available in 18, 20 or 22 gage. Aluminum panels—mill or grained finish—are available in 14, 16, 18 or 20 B&S gage. A combination of aluminum exterior face and galvanized steel interior face is also manufactured. Interior faces of panels may be flat or have small V-shaped ribs.

Maximum girt spacings for all-steel panels is 11′-0″ for simple spans and 13′-0″ for double spans; for all-aluminum or aluminum-steel panels, 7′-6″ and 8′-6″.

Material and erection costs for field assembled wall panels total practically the same as given on previous pages for shop assembled panels of similar materials.



Fenmark Curtain Wall

Uninsulated Siding.—Exterior face panels of field assembled wall panels described above are available for uninsulated siding installations in galvanized steel and aluminum.

Coverage width is 24"; depth, 1½"; lengths, 6'-0" to 31'-0".

Cost of siding, delivered to job site; galvanized steel, $0.55 per sq. ft.; aluminum, $1.00 per sq. ft.

Erection of siding, by bolting or welding, costs about $0.25 per sq. ft.

Movable Fire Partitions.—Movable fire partitions, long needed in industrial plants, are now available for installation where permanent fire walls are not desired. One such partition has a 2½ hour fire rating.

These lightweight partitions are formed of two 18 gage galvanized steel, 1½" deep fluted sheets of the same type as used for exterior face of field assembled wall panels. Four ½" laminations of gypsum board, containing glass fibers and unexpanded vermiculite, are inserted between the sheets and the build-up is held together by bolts.

Depth of the fire partition is 5" and coverage width per section is 24". Length of section varies with ceiling to floor dimension.

Fire partitions are lightweight and easily erected. Portable attachment to structural steel is by bolting—permanent attachment is by welding.

Cost in place of movable fire partitions is approximately $2.40 per sq. ft.

Curtain Wall Construction.—Buildings of all types are now using the curtain wall method of exterior wall construction, in preference to the conventional masonry, for the following reasons:

Curtain walls are lightweight, permitting substantial savings in structural framing and foundations.

Units are thin—varying from 1¼" to 4½"—increasing ratio of usable floor area to total building area.

They provide good insulation with the use of efficient insulating filler materials and smooth reflective exterior and interior surfaces.

The large prefabricated and shop assembled panels, containing window units, spandrels, mullions, etc., are erected rapidly, reducing labor costs and permitting earlier completion and occupancy of building.

Curtain wall materials are practically self-cleaning and require a minimum of maintenance.

At the present time, curtain walls must be designed and fabricated to order to fit a particular job. Each job is custom built and costs vary considerably depending upon design, ma-

terials used, size of units, amount of duplication, type of windows, secondary framing requirements, etc. Where curtain walls are contemplated, it is customary for the owner, designer and curtain wall fabricator to negotiate an approximate figure for budget purposes, which is also set up as an allowance for contractors to use when preparing an estimate on the total work.

Materials commonly used for curtain wall panels are painted, galvanized or stainless steel, aluminum and porcelain enameled steel or aluminum. Various combinations of these materials are also used.

Various types of windows may be used including intermediate projected, casement or combination types, awning type, reversible windows and others.

Panel sizes vary considerably, but most economical designs for multiple story structures have a coverage width of about 4'-0" and a story to story height of 10'-0" to 12'-0". For 2 and 3 story structures, full height panels have been used successfully —to date, total height limit has been about 30'-0".

The following average curtain wall costs are given for preliminary estimating purposes only. Always obtain firm figures for curtain walls before submitting bid, unless an allowance has been set up for this work.

Description	Approx. Cost Per Sq. Ft.
Painted or galvanized steel frames and spandrels	$2.50 to $4.00
Painted or galvanized steel frames and porcelain enameled steel spandrels	3.00 to 4.50
Aluminum frames and spandrels	5.50 to 7.50
Aluminum frames and porcelain enameled steel spandrels	5.00 to 7.00
Stainless steel frames and spandrels	6.00 to 8.00

The above costs include windows frames, sash and field erection. No glass, glazing or field painting are included.

Porcelain Enamel Veneer Panels.—Pan type porcelain enameled steel panels are designed for application as a veneer over practically all types of wall surfaces, including masonry, plaster, wood and others. May be used for both exterior and interior facing and is equally adaptable to both new construction and remodeling work.

Porcelain enamel veneer panels are available with plain or formed surfaces and may be shaped to practically any contour. Stainless steel mounting lugs are welded to backs of panels for fastening to wood or metal furring strips attached to wall surface or framing. Joints may be caulked or sealed with extruded plastic gasket material.

Installed costs for porcelain enamel veneer panels vary, depending upon size of job, type of panels, amount of duplication, etc. A simple job, involving only a few sizes of flat panels with no corners, may cost as little as $2.00 per sq. ft. The average job, involving facing, coping, facia, window and door reveals and returns, should cost about $2.50 per sq. ft. A difficult job, with complicated shapes and panels, may cost $3.00 to $3.50 per sq. ft. All costs given include erection, furring strips and joint treatment.

NAILABLE STEEL STRUCTURAL FRAMING CONSTRUCTION*

The Penn Metal system of building construction is a complete high tensile lightweight nailable steel framing system. The components involved are a complete range of studs, joists and accessories for the steel framing of buildings. Sections are fabricated from structural-grade, high tensile strip steel by cold forming and are designed specifically for strength, light weight and low cost. Yet, structural framing carries all the benefits of conventional steel framing.

The nailing groove, developed for easy, economical attachment of collateral materials, is a feature of all double studs and joists. It is obtained by welding two cold-formed steel elements together, so designed that a nail driven into this space is not only held by friction, but is also deformed to provide maximum holding power.

For the first time, the light building field can adopt steel framework economically. Residential construction, schools, light industrial and commercial structures, load-bearing partitions and exterior curtain wall framing in multiple story buildings—all hitherto largely limited to the use of other less desirable building materials—can now enjoy all the advantages of a steel framing system designed specifically for such construction.

The usual limitations imposed by prefabrication are avoided. Using nailable framing sections architects and engineers have unrestricted freedom in design. All sections are painted at the plant with a coat of oven-dried, rust-resisting red zinc chromate paint.

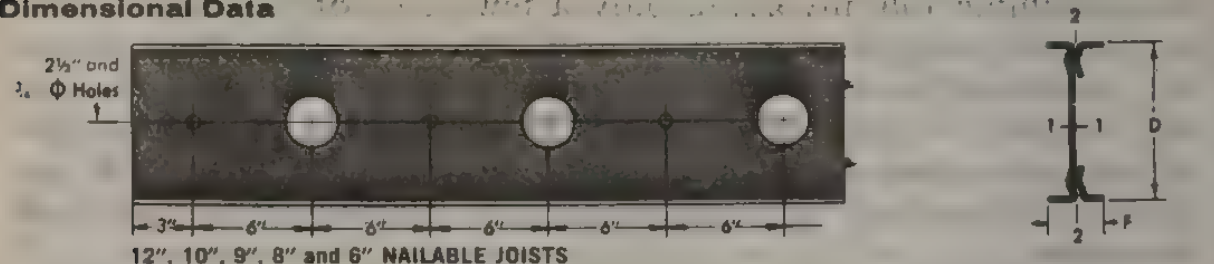
Cost of Penn Metal Framing Systems.—The contractor should always get a firm figure from a Penn Metal distributor before bidding on this work. However, for purposes of comparison and preliminary estimating, the following information may prove useful.

Penn Metal roof and floor joist systems are estimated by the square foot of area. Joists cut to exact lengths and delivered to the

*Penn Metal Div. Keene Corp., Parkersburg, West Virginia

NAILABLE JOISTS, NAILABLE STUDS, UNPUNCHED CHANNEL and TRACK, V-BAR BRIDGING

Dimensional Data

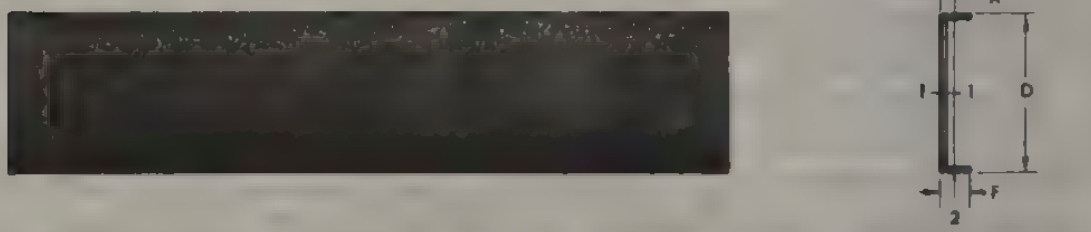


12", 10", 9", 8" and 6" NAILABLE JOISTS

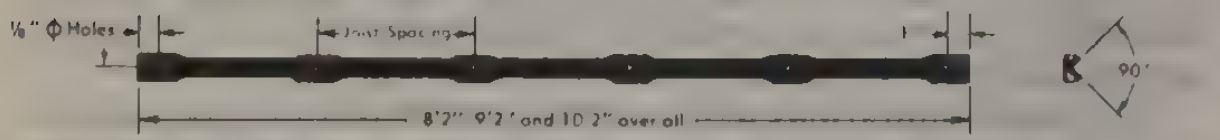
4" NAILABLE DOUBLE STUDS

3⅝" NAILABLE DOUBLE STUDS

2½" NAILABLE DOUBLE STUDS



UNPUNCHED CHANNEL AND TRACK



V-BAR BRIDGING*

(Weight = 0.26 lbs. ft., gage = 16; t = 0.0568", net area 0.075 sq. in.)

Lengths

Punched Joists 16' through 36' in 2' increments
Double Studs: 20', 25'0½", 30' and 32'
Track 20' (except 12" track 10')

ABLE 1 Physical and Structural Properties

Section	Depth in.	Flange in.	Web	Thickness	Weight Lbs.	Net Area	Allowable Compression Stress	Moment of Inertia	Column Factor	About Minor Axis 1-1			About Minor Axis 2-2			
												r in Stress			r in Stress	
ILABLE JOISTS*																
	12	2⅞	12	0.100	6.739	1.700	29,720	196,440	0.69	39.67	6.61	4.45	0.41	0.29	0.45	
	12	2⅝	14	0.075	5.101	1.275	26,030	128,840	0.58	29.71	4.95	4.45	0.27	0.20	0.43	
	10	2⅝	12	0.100	6.105	1.550	29,720	151,270	0.76	25.46	5.09	3.76	0.41	0.29	0.48	
	10	2⅝	14	0.075	4.579	1.163	26,030	99,430	0.64	19.08	3.82	3.76	0.28	0.21	0.46	
	10	2⅝	15	0.070	4.005	1.008	29,330	93,560	0.67	15.95	3.19	3.67	0.13	0.12	0.33	
	9	2⅝	14	0.075	4.317	1.088	26,030	85,370	0.67	14.76	3.28	3.40	0.27	0.20	0.46	
	9	1⅝	16	0.060	3.119	0.774	29,910	65,800	0.70	9.90	2.20	3.27	0.07	0.07	0.28	
	8	2⅝	14	0.075	4.075	1.013	26,030	72,100	0.71	11.08	2.77	3.04	0.28	0.20	0.48	
	8	1⅝	16	0.060	2.910	0.714	29,910	55,030	0.74	7.36	1.84	2.92	0.07	0.07	0.29	
	6	2⅝	14	0.075	3.533	0.863	26,030	47,630	0.71	5.49	1.83	2.29	0.28	0.20	0.51	
	6	1⅝	16	0.060	2.692	0.594	29,910	35,290	0.80	3.55	1.18	2.19	0.07	0.08	0.31	
	6	1⅜	18	0.048	1.986	0.475	27,180	25,820	0.72	2.84	0.95	2.18	0.05	0.06	0.30	
NCHED NAILABLE DOUBLE STUDS																
	4	1⅝	16	0.060	2.189	0.503	29,910	19,440	0.77	1.30	0.65	1.41	0.07	0.07	0.32	
	4	1⅝	18	0.048	1.682	0.384	19,460	9,340	0.74	0.97	0.48	1.39	0.04	0.05	0.27	
	3⅝	2⅝	15	0.070	2.682	0.623	26,380	21,100	0.69	1.46	0.80	1.35	0.20	0.16	0.50	
	3⅝	1⅝	16	0.060	2.074	0.458	30,000	16,800	0.75	1.01	0.56	1.29	0.07	0.07	0.35	
	3⅝	1⅜	18	0.048	1.555	0.348	19,460	7,970	0.72	0.75	0.41	1.27	0.03	0.04	0.27	
	2½	1⅝	16	0.060	1.631	0.383	30,000	9,900	0.81	0.41	0.33	0.93	0.07	0.07	0.38	
	2½	1⅜	18	0.048	1.208	0.282	19,770	4,540	0.79	0.29	0.23	0.83	0.03	0.04	0.29	
NPUNCHED NAILABLE DOUBLE STUDS																
	4	1⅝	16	0.060	2.274	0.653	29,910	19,740	0.86	1.32	0.66	1.42	0.07	0.07	0.32	
	4	1⅜	18	0.048	1.750	0.504	19,460	9,530	0.83	0.98	0.49	1.40	0.04	0.05	0.27	
	3⅝	2⅝	15	0.070	2.781	0.798	26,380	21,630	0.84	1.48	0.82	1.36	0.20	0.16	0.50	
	3⅝	1⅝	16	0.060	2.117	0.608	30,000	17,100	0.90	1.03	0.57	1.30	0.07	0.07	0.35	
	3⅝	1⅜	18	0.048	1.625	0.468	19,460	8,170	0.87	0.77	0.42	1.28	0.03	0.04	0.27	
	2½	1⅝	16	0.060	1.647	0.473	30,000	9,900	1.00	0.41	0.33	0.94	0.07	0.07	0.38	
	2½	1⅜	18	0.048	1.229	0.354	19,770	4,740	0.99	0.30	0.24	0.92	0.03	0.04	0.29	
GAGE UNPUNCHED TRACK																
	12⅜	¾	16	0.060	2.812	0.807	29,850	58,200	0.31	11.89	1.95	3.84	0.02	This property, rarely required, varies depending on whether the web is in tension or compression	0.14	0.07
	10⅜	¾	16	0.060	2.394	0.687	29,850	40,890	0.36	6.97	1.37	3.19	0.01		0.15	0.08
	9⅜	¾	16	0.060	2.185	0.627	29,850	35,820	0.40	5.49	1.20	2.96	0.01		0.15	0.08
	8⅜	¾	16	0.060	1.976	0.567	29,850	29,250	0.43	4.02	0.98	2.66	0.01		0.16	0.09
	6⅜	1½	16	0.060	1.784	0.512	19,655	16,020	0.43	2.52	0.82	2.22	0.06		0.33	0.22
	4⅜	1½	16	0.060	1.359	0.392	19,655	9,060	0.53	0.96	0.46	1.57	0.05		0.35	0.27
	3⅜	1¼	16	0.060	1.287	0.371	19,655	8,020	0.56	0.78	0.41	1.45	0.05		0.36	0.29
	3⅜	1¼	16	0.060	1.209	0.349	19,655	6,820	0.58	0.60	0.35	1.31	0.05		0.37	0.31
	2⅜	1¼	16	0.060	1.059	0.306	19,655	5,050	0.63	0.35	0.26	1.07	0.04		0.38	0.36
GAGE UNPUNCHED TRACK																
	6⅜	1¼	18	0.048	1.430	0.413	13,400	8,830	0.43	2.04	0.66	2.23	0.05		0.34	0.21
	4⅜	1¼	18	0.048	1.097	0.317	13,400	5,800	0.54	0.91	0.43	1.69	0.04		0.36	0.27
	3⅜	1¼	18	0.048	1.034	0.299	13,400	4,440	0.56	0.63	0.33	1.46	0.04		0.37	0.28
	3⅜	1¼	18	0.048	0.972	0.281	13,400	3,860	0.58	0.50	0.29	1.33	0.04		0.38	0.30
	2⅜	1¼	18	0.048	0.844	0.244	13,400	2,770	0.64	0.28	0.21	1.07	0.04		0.38	0.34

In Accordance with A.I.S.I. Specification of Latest Adoption for the Design of Light Gage Steel (1962)

steel in all sections meets the requirements of A S T M specification designa- A570-66T (formerly A 245), Grade D, of latest adoption, except minimum yield t is 50,000 psi instead of 40,000 psi (18-gage double studs are commercial ity steel with a yield point of 33,000 psi).

punched joists available on special rolling

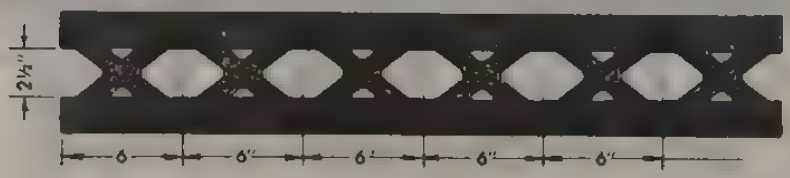
**Reduced working stress, based on a yield point of 50,000 psi, which allows a maximum design stress of 30,000 psi (Section 3.2.b, 1962 A.I.S.I. Code).

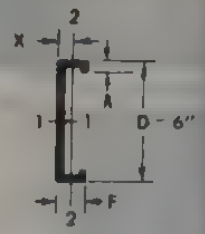
***Available only in 10' lengths

†Available on special rolling only

SCREW CEE STUDS, SCREW STUDS, CHANNEL STUDS

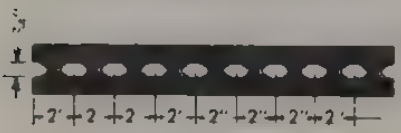
Dimensional Data



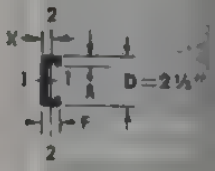


6" SCREW CEE STUDS

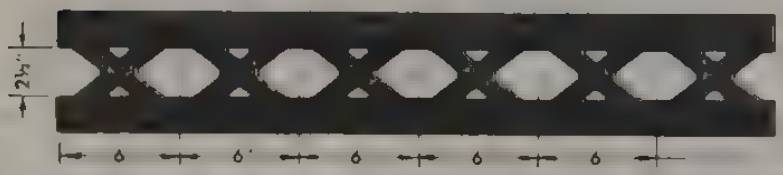
4", 3⅜", 3¼" SCREW CEE STUDS

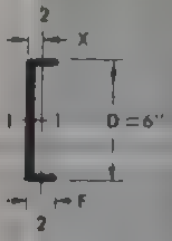


Dimension A: 0.4" for all gages.

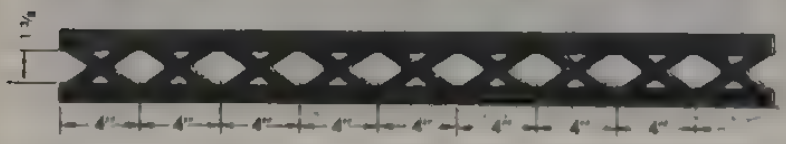


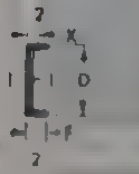
2½" SCREW CEE STUDS



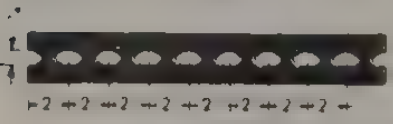


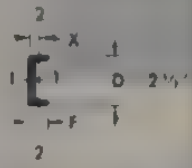
6" PUNCHED SCREW STUDS AND CHANNEL STUDS





3⅜" PUNCHED SCREW STUDS AND 3¼", 3⅜" AND 4" CHANNEL STUDS





2½" PUNCHED SCREW STUDS AND CHANNEL STUDS

Lengths

Screw CEE Studs, Screw Studs, Channel Studs, and unpunched Channels 20', 24' and 32'

BLE 2 Physical and Structural Properties

ction gnation	Depth in. D	Flange in. F	Nominal Gage	Thickness in.	Net Weight Lbs. Per Ft.	Net Area Sq. In.	Allowable Compression Stress f_c psi**	Res. Moment Mx x in lbs.	Column Factor Q	About Major Axis 1-1			About Minor Axis 2-2			
										I in.⁴	S in.³	r in. Gross Area	I in.⁴	S in.³	r in. Gross Area	I in.
HED SCREW CEE STUDS* **																
S16PUN	6	1 7/8	.6	.060	1 6.7	0 398	30 000	25 870	644	2 537	862	2 2.5	0 09	0 07	0 49	0 42
S18PUN	6	1 7/8	18	048	1 289	0 318	20 000	13 790	635	2 077	690	2 2.5	0 08	0 05	0 49	0 40
S20PUN*	6	1 3/8	20	036	0.981	0 243	19 830	9 900	.559	1 497	499	2 201	0 07	0 05	0 53	0 40
S16PUN	4	1 3/8	.6	060	1 325	0 345	30 000	14 920	792	995	497	1 540	0 09	0 06	0 50	0 48
S18PUN	4	1 3/8	18	048	1 057	0 276	20 000	8 010	787	801	401	1 545	0 07	0 05	0 50	0 46
S20PUN*	4	1 3/8	20	036	0.806	0 212	19 830	5,700	706	577	288	1 539	0 05	0 04	0 50	0 46
S16PUN	3 1/2	1 3/8	16	060	1 246	0 323	30 000	13 000	795	786	434	409	0 08	0 06	0 51	0 51
S18PUN	3 1/2	1 3/8	18	048	0 994	0 258	20 000	6 990	795	634	350	1 415	0 06	0 05	0 50	0 50
S20PUN*	3 1/2	1 3/8	20	036	0 759	0 198	19,830	4,980	740	456	252	410	0 05	0 04	0 51	0 49
S16PUN*	3 1/4	1 3/8	16	060	1 168	0 300	30 000	11 170	783	605	372	276	0 08	0 05	0 51	0 54
S18PUN*	3 1/4	1 3/8	18	048	0 932	0 240	20,000	6 020	.785	489	30.	.282	0 06	0 04	0 51	0 53
S20PUN*	3 1/4	1 3/8	20	036	0 712	0 184	19,830	4,280	769	352	2.6	.279	0 04	0 03	0 51	0 52
S16PUN	2 1/2	1 3/8	16	060	.074	0 293	30 000	8 000	866	333	267	001	0 07	0 05	0 51	0 56
S18PUN	2 1/2	1 3/8	18	048	0 856	0 234	20,000	4 330	866	270	216	.003	0 06	0 04	0 51	0 54
S20PUN*	2 1/2	1 3/8	20	036	0 657	0 180	19 830	3 080	853	195	156	1 009	0.04	0 03	0 51	0 54
CHED SCREW STUDS* **																
16PUN	6	1 3/8	16	0 060	1 492	0.362	18 240	14 230	0 42	2 34	0 78	2 54	0 06	0 04	0 39	0 33
18PUN	6	1 3/8	18	0 048	1 197	0 291	12 270	7 700	0 42	1 88	0 62	2 55	0 04	0 03	0 42	0 33
20PUN*	6	1 3/8	20	0 036	0 903	0 219	6 765	3,240	0 23	1 42	0 47	2 55	0 04	0 06	0 42	0 32
16PUN	4	1 3/8	16	0 060	1 188	0 309	18 150	8 130	0 476	0 896	0 448	1 701	0 06	0 04	0 44	0 38
18PUN	4	1 3/8	18	0 048	0.956	0 248	12 270	4 440	0 484	0 724	0 362	1 706	0 04	0 03	0 40	0 38
20PUN	4	1 3/8	20	0 036	0 720	0 187	6,765	1,860	0 267	0 549	0 274	1 711	0 04	0 03	0 44	0 37
16PUN	3 1/2	1 3/8	16	0 060	1 12.	0 287	.8 240	7 .50	0 47	0 70	0 39	.56	0 05	0 05	0 44	0 41
18PUN	3 1/2	1 3/8	18	0 048	0 902	0 231	12 270	3 850	0 48	0 57	0 31	1 57	0 03	0 03	0 40	0 40
20PUN*	3 1/2	1 3/8	20	0 036	0 684	0 174	6 765	1 660	0 26	0 44	0 24	1 60	0 03	0 03	0 44	0 40
16PUN*	3 1/4	1 3/8	16	0 060	1 032	0 264	18 .50	6,080	0 461	0 544	0 335	1 435	0 05	0 04	0 48	0 44
18PUN*	3 1/4	1 3/8	18	0 048	0 831	0 192	12 270	3,320	0 468	0 440	0 270	15.1	0 03	0 02	0 40	0 48
20PUN*	3 1/4	1 3/8	20	0 036	0 627	0 160	6 765	1,390	0 258	0 335	0 206	.445	0 03	0 02	0 45	0 43
16PUN	2 1/2	1 3/8	18	0 060	0 956	0 257	18 240	4 400	0 52	0 30	0 24	.08	0 05	0 05	0 44	0 46
18PUN	2 1/2	1 3/8	16	0 048	0 762	0 207	12 270	2 400	0 52	0 24	0 19	1 08	0 03	0 03	0 40	0 45
20PUN*	2 1/2	1 3/8	20	0 036	0 581	0 156	6 765	1 000	0 29	0 18	0 .4	1 09	0 03	0 03	0 45	0 44
CHED CHANNEL STUDS																
S18PUN	6	1/8	16	0 060	1 266	0 298	30 000	17 820	0 57	1 78	0 59	2 00	0 02		0 19	0 16
S18PUN*	6	1 3/16	18	0 048	1 009	0 238	18 470	8 760	0 53	1 42	0 47	1 99	0 01		0.21	0 16
S16PUN	4	1/8	16	0 060	0 971	0 245	30 000	9 820	0 74	0 65	0 32	1 41	0 01		0 22	0 19
S18PUN*	4	1 3/16	18	0 048	0 774	0.196	18,470	4,790	0 69	0.52	0 26	1 4.	0 01		0 24	0 18
S18PUN	3 1/2	1/8	16	0 060	0 893	0 223	30 000	8 340	0 73	0 50	0 28	1 29	0 01		0 22	0 21
S18PUN*	3 1/2	1 3/16	18	0 048	0 712	0 178	18 470	4 120	0 67	0 40	0 22	1 29	0 01		0 24	0 15
S16PUN*	3 1/4	1/8	16	0 060	0 814	0 200	30,000	7 040	0,71	0 38	0 23	1 16	0 01		0 22	0 23
S16PUN*	3 1/4	1 3/16	18	0 048	0 649	0 160	18,470	3 480	0 65	0 31	0 19	1 16	0 01		0 24	0 22
S16PUN	2 1/2	1/8	16	0 060	0 720	0 193	30 000	4 950	0 81	0 21	0 17	0 93	0 01		0 24	0 24
S18PUN*	2 1/2	1 3/16	18	0 048	0 574	0 154	18,470	2 450	0 75	0 17	0 13	0 93	0 01		0 26	0 23
UNCHED CHANNELS																
6UNP	6	1/8	16	0 060	1 558	0 448	30,000	18 600	0 57	.86	0 62	2 04	0 02		0 19	0 12
8UNP*	6	1 3/16	18	0 048	1 242	0 358	18 470	9 140	0 53	1 49	0 50	2 04	0 01		0 19	0 11
6UNP	4	1/8	16	0 060	.137	0 328	30,000	9,900	0 74	0 66	0 33	1 42	0 02		0 22	0 15
8UNP*	4	1 3/16	18	0 048	0 906	0 262	18,470	4,890	0 69	0 53	0 26	1 42	0 01		0 21	0 14
6UNP	3 1/2	1/8	.6	0 060	1 059	0 305	30 000	8 550	0 78	0 52	0 29	1 30	0 01		0 22	0 16
8UNP*	3 1/2	1 3/16	18	0 048	0 843	0 244	18 470	4,220	0 73	0 4.	0 23	1 31	0 01		0 22	0 15
6UNP*	3 1/4	1/8	16	0 060	0 980	0 283	30 000	7 280	0 83	0 39	0 24	1 18	0 01		0 23	0 17
8UNP*	3 1/4	1 3/16	18	0 048	0 781	0 226	18,470	3 600	0 77	0.32	0 20	1 18	0 01		0 22	0 16
6UNP	2 1/2	1/8	16	0 060	0 823	0 238	30,000	5,000	0 93	0 21	0 17	0 94	0 01		0 24	0.20
8UNP*	2 1/2	1 3/16	18	0 048	0 656	0 190	18 470	2,480	0 86	0 17	0 13	0 94	0 01		0 23	0 19

This property, rarely required, varies depending on whether the web is in tension or compression

In Accordance with A.I.S.I. Specification of Latest Adoption for the Design of Light Gage Steel (1962)

ee .in .6 gage sections meets the requirements of of A.S.T.M. specification, ation A570-66T (formerly A-245), Grade D, of latest adoption, except minimum point is 50,000 psi instead of 40,000 psi. (18- and 20-gage sections are ercial-quality steel with a yield point of 33,000 psi.)

**Reduced working stress based on a yield point of 50,000 pounds per square inch which allows a maximum design stress of 30,000 pounds per square inch

***.6 and 18 gage screw cee studs and screw studs have knurled flanges to accommodate self-drilling, self-tapping screws.

ble on special rolling

SOLID BRIDGING AND PLATE BEAMS

Dimensional Data

SOLID BRIDGING

Lengths
Solid Bridging: 20'
Plate Beams: No length restrictions

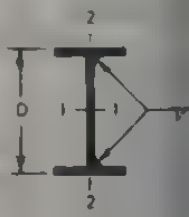


PLATE BEAMS

TABLE 3 Physical and Structural Properties

SOLID BRIDGING

Section Designation	Depth in.	Flange in.	Gage	Thickness	Wt. per Ft. lbs.	Wt. per Sq. Ft. lbs.	Moment of Inertia I	Section Modulus S	Radius of Gyration r	Shear V/d	Moment M	Deflection	Shear V/d	Moment M	Deflection
	3 1/16	1/16	16	0.066	1.558	0.447	26.440	16.390	0.54	1.81	0.62	2.01	0.03		0.24	0.4
	3 1/16	3/16	16	0.060	1.059	0.304	29.970	8.690	0.75	0.55	0.29	1.34	0.01		0.20	0.13
	3 5/16	3/16	16	0.060	0.980	0.281	29.970	7.490	0.80	0.42	0.25	1.22	0.01		0.21	0.14
	2 5/16	1/16	16	0.060	0.823	0.236	26.450	4.230	0.85	0.19	0.16	0.89	0.02		0.29	0.24

In Accordance with A.I.S.I. Specification of Latest Adoption for the Design of Light Gage Steel (1962)

The steel meets the requirements of A.S.T.M. specification designation A570-66T (formerly A 245 Grade D of latest adoption except minimum yield point is 50 000 psi instead of 40 000 psi

* Reduced working stress based on a yield point of 50 000 pounds per square inch which allows a maximum design stress of 30 000 pounds per square inch

PLATE BEAMS

Section Designation	Weight lbs. per ft.	Area sq. in.	Depth in.	Flange in.	Thickness	Web Thickness in.	Moment of Inertia I-I	Section Modulus I-I	Radius of Gyration I-I	Moment of Inertia 2-2	Section Modulus 2-2	Radius of Gyration 2-2
	23.04	6.27	12.75	8.00	3/8	188	221.3	34.7	5.52	26.7	6.7	2.06
	21.64	6.27	12.62	8.00	250	188	181.0	28.7	5.37	21.3	5.3	1.84
	23.74	6.90	10.75	8.00	312	188	152.4	28.4	4.70	26.7	6.7	1.97
	20.34	5.90	10.62	8.00	250	188	123.9	23.3	4.58	21.3	5.3	1.90
	23.08	6.71	9.75	8.00	312	188	123.2	25.3	4.29	26.7	6.7	1.99
	16.28	4.71	9.62	6.00	250	188	77.8	16.2	4.06	9.0	3.0	1.38
	22.43	6.52	8.75	8.00	312	188	97.4	22.3	3.86	27.6	6.7	2.02
	15.63	4.52	8.62	6.00	250	188	61.0	14.1	3.67	9.0	3.0	1.41

Plate beams may be purchased from Penn Metal Operation or fabricated locally. They shall be manufactured from A.S.T.M. Type A 36 steel. Allowable unit bending stress, F_b 22 000 psi and shall be designed on the basis of a non-[illegible]

b site will cost from 55 to 70 cts. per sq. ft. for roofs and light oor systems. Estimate 75 to 90 cts. per sq. ft. for heavy floor ads. Field erection of this material ranges from 5 to 7 cts. per .ft. for roofs and 10 to 15 cts. for floors.

Penn Metal stud systems are estimated by the square foot of ll area. Studs and track sections are usually shop fabricated to wall panels by the local Penn Metal distributor and should st 60 to 75 cts. per sq. ft. delivered to the job site. The cost of ld erection varies from 10 to 16 cts. per sq. ft.

Penn Metal trusses, shop fabricated from zee sections, studs, ack and bridging, may be used for roof framing for clear spans to about 40′-0″. These trusses are light in weight and may be ndled manually without the need of cranes or special handling uipment. The average 40′-0″ span truss weighs about 200 lbs. and e avĕrage short span truss weighs about 100 lbs.

Estimating cost of trusses is accomplished by determining the rizontal projected area of the roof. Material costs of shop fabri- ted trusses, delivered to the job site, will vary from $1.50 to .70 per sq. ft. for 40′-0″ clear span trusses. Short span trusses st approximately $1.20 to $1.45 per sq. ft. Field erection of usses varies from 17 to 19 cts. per sq. ft. of horizontal projected ea.

Bolt Hole Punching.—When required, flanges and webs will be nched, at a nominal charge, with ⅝″ holes. Flange punching is signed for bolting the sections to rigid bents or trusses, and eb punching is used for quick insertion of sag rods or horizontal acing. Prices and drawings covering standard punching will be rnished on request. If special punching is required, submit awings for quotation.

Attachment of Collateral Materials.—Steel or aluminum roof cking, metal siding or corrugated sheets can be quickly and onomically attached to Penn Metal sections with self-tapping rews, or by other conventional methods.

When self-tapping screws are used, a hole slightly smaller than e screw is drilled through the collateral material and the Penn etal section. Then, the screw can be placed and tightened by one an. This is faster and more economical than most conventional ethods of attachment which require two men. ⅝″ hex-head self- pping, cadmium-plated "Top Seal" screws, as manufactured by abricated Products Company, West Newton, Pa., or equal, are commended. Copies of complete specifications for self-tapping rews and samples are available upon request.

Attachment of collateral materials is generally with standard

nails when the nailable sections are used. When channel studs o other non-nailable sections are used, the "Buildex" self-drillin screw is recommended for metal siding or plywood. When drywal is applied to non-nailable sections, the bugle head self-drillin screw S-12 by U. S. Gypsum is recommended.

Other types of collateral materials can be readily attached t Penn Metal framing members by the use of bolts, clips, welds o other methods consistent with the finish desired.

CHAPTER XXVII

ELECTRIC AND HYDRAULIC ELEVATORS

Elevator construction is such a highly specialized business at it is practically out of the question to expect anyone except experienced elevator engineer to prepare an estimate on equipnt of this kind.

There are many items entering into the construction of an evator which affect the cost. All of the well known elevator anufacturers submit their quotations on an installed basis and e location of the job must be taken into consideration as well as tended use, the capacity, the car speed, the size of the car, the avel, the number of stops, and openings, the design of the car and e kind of current available.

In addition there are many types of controls, such as car switch, ntinuous pressure push button, single call push button, up wn collective (for operation with an operator or automatic eration) signal control, duplex and others.

Almost all modern passenger elevator installations have some gree of automatic control if they are not completely automatic. new office buildings computerized systems are available which cognize traffic demands and automatically program elevator rvice to these demands. With these programming systems elevar service is made as efficient as possible during peak or down riods.

Elevator Safety Codes

Many states and cities have their own elevator code, and all vator installations must comply with the rules and regulations that state or city. In general, all municipal or state codes folw closely the American Safety Code for Elevators, Dumbwaiters d Escalators, ASA Standard A 17.1-1960, with its supplement SA A17-1a-1963, and the American Standard Safety Code Rules r Moving Walks ASA A17.1.13-1962. It would be well for anye endeavoring to estimate the cost of an elevator to familiarize mself with these codes. For example, the capacity of a passenger vator must be based upon the effective area of the car platform accordance with the contract load graphs shown in the latest

edition of the American Standard Safety Code for Elevators Dumbwaiters and Escalators.

Essential Information for Figuring Elevators.—The followin information is essential to enable the elevator manufacturer t prepare an intelligent estimate on the elevators required for an building.

1. Name of building
2. Location of building
3. Name and address of owner
4. Name and address of architect
5. Number of elevators
6. Use of elevator (passenger, freight or general purpose)
7. Capacity of elevators
8. Car speed of elevators
9. Controls and operation of elevators
10. Type of motor (single speed, two speed, or variable voltage)
11. Total travel of elevator in feet
12. Number of stops and openings
13. Single or double entrance car
14. Location and size of elevator machinery room or penthouse
15. Kind of current available
16. Size of hatch or platform
17. Design of cab, doors and frames
18. Compensating chain or cables
19. Car and hatch door power operators
20. Hatchway doors (single speed, two speed or center opening for passenger elevators; metal clad bi-parting counterbalanced doors or lift-up hatchway gates for freight elevators)
21. Signals
22. Hatchway lighting
23. Access door location

Costs of Electric and Hydraulic Elevators.—The cost of an elevator is a function of its speed, capacity and type of control which in turn are determined by type of building to be served, the use of the elevator and the height of the building or feet of travel of the elevator.

There are so many factors that enter into the cost that an estimator should get definite prices from an elevator engineer if possible. The following budget figures may be used for rough estimating only.

Electric Elevators:

1. **General Purpose and Hotels**
   High rise passenger elevator

Gearless machines
Variable voltage control—operatorless
Center-opening hoistway and car doors
$4,000.00 car allowance
Basic cost for 10-story building

CAPACITY	SPEED		
	500 fpm	800 fpm	1000 fpm
2500 lbs.	$66,000	$86,000	$ 95,000
3000 lbs.	69,000	89,000	100,000
3500 lbs.	74,000	92,000	106,000
4000 lbs.	80,000	98,000	110,000

For each floor above 10, add $2,000 per floor.

Many tall building elevators now operate at speeds up to 1800 fpm-but these require special pricing, depending on express and local runs.

2. **General Purpose—Hospitals, Hotels and Apartments**
Low rise elevators
Geared machines
Variable voltage control—operatorless
Center-opening hoistway and car doors
$3500 car allowance
Basic cost for 8-story building

CAPACITY	SPEED		
	200 fpm	300 fpm	400 fpm
2000 lbs.	$33,000	$35,000	$41,000
2500 lbs.	36,000	39,000	46,000
3000 lbs.	40,000	42,000	52,000
4000 lbs.	45,000	46,000	56,000

For each floor less than 8—deduct $1,500 per floor.

3. **Apartments or Hospitals**
Low rise elevators—12 foot story heights
Geared machines
AC operation and control
Center opening hoistway and car doors
$3,000 car allowance
Basic costs for 6-story building

CAPACITY	SPEED	
	100 fpm	150 fpm
1500 lbs.	$23,000	$26,000
2000 lbs.	26,000	29,000
3000 lbs.	29,000	31,000
4000 lbs.	32,000	35,000

For each floor less than 6—deduct about $1500 per floor.

Oil Hydraulic Elevators.—There has been considerable improvement in oil hydraulic elevators in recent years. Rise is limited to about 65 ft. so that they can be used for 5 or 6-story buildings. They are more economical to install and require no overhead penthouse and therefore no load bearing walls or frame. They are available in speeds up to 200 fpm and nearly any capacity. Loads of 100,000 lbs. and more can be handled.

The cost of an oil hydraulic installation should include the drilling of the hole for the plunger. This depends on local conditions such as soil, water, rock, etc. The oil hydraulic elevators range in price from $6,000.00 upwards, depending on size, speed, control and purpose.

A 2000 lb., 125 fpm hydraulic elevator, serving 4 stories with 4 openings and a vertical run of some 30 ft. complete with all motors, pumps, controls, piping, drilling, cab, doors and frames, etc., will cost about $20,000.00.

Garage Elevator.—Freight elevator, single call push button control, two-speed motor, automatic leveling, capacity 6,000 lbs., speed 100'-0" per minute. Total rise 36'-0" with 4 stops and 4 openings. Car platform 10'-0"x20'-0". Car built of steel wainscoting on 2 sides 6'-0" high, a steel car top and two wood or expanded metal lift-up gates with electric contacts. Price installed $26,000.00. No doors or hatchway gates included.

Residence Type Elevators.—During recent years residence type elevators have become quite popular, especially where there are older people or invalids in the house. These elevators are easily installed both in new homes and homes already built.

A typical residential elevator, 350 lbs. capacity, Speed 20'-0" per min. Total travel 11'-0", 2 stops and 2 openings, 110 or 220 volts, single phase 60 cycles. Platform 34"x30". Price installed approximately $3,000.00. Add for each additional stop, $800.00.

Same elevator as above with 40"x36" platform. Price installed approximately $3,400.00. Add for each additional stop, $800.00.

CHAPTER XXVIII

HEATING AND AIR CONDITIONING

In recent years, much improvement has been made in the methods of heating and cooling buildings, especially in residential work, largely due to the research programs conducted by heating and air conditioning associations, engineering societies, equipment manufacturers and research departments of various universities.

Types of Conventional Heating Systems.—There are four basic types of conventional heating systems—warm air, hot water, steam and electric, each of which may be used separately or in combination. Electric heating is discussed in Chapter XXX.

For small to medium size residences, stores, churches, etc., of similar size and construction, warm air systems are most widely used. For medium size to large residences and non-residential structures of comparable size, hot water systems are usually selected. For large scale installations, steam systems are generally required. Inasmuch as there are no definite rules stating just when to select one system in preference to another, there is much overlapping in their application. An owner's preference for a particular system may be governed by initial cost of installation; operation cost; convenience of operation; adaptability of system to other uses, such as summer cooling using ducts of a warm air system, snow melting using hot water piping connected to a hot water system; fuel availability, and aesthetics.

Panel Heating Systems.—Panel heating systems are used in residential work and for some non-residential structures as well. These systems use large areas of room surfaces, heated to relatively low temperatures (80° to 100°F.), as radiant panels. Panels usually are heated by warm water piping, warm air ducts or low temperature electrical resistance elements embedded in, or located behind, ceiling, wall or floor surfaces.

At the present time, the warm water piping method is most frequently used, with the piping embedded in concrete floors or plastered ceilings—in some cases, both floors and ceilings are

used as radiant panels. Piping in floors is usually welded joint black wrought iron pipe, steel pipe or copper tubing. For installations in plastered ceilings copper tubing is usually used.

Estimating the Cost of Heating Systems.—There is no fast, easy, "rule of thumb" method for estimating the cost of a heating system. This requires expert knowledge, as most jobs must be designed and laid out before they can be estimated. In residential and small commercial work, architects seldom give more information than merely specifying the type of system desired, the performance expected, and the kinds of material to use. It is then up to the heating contractor to figure the heating loads and design a system to fit the conditions before estimating the job. On larger work, the heating system is usually designed and laid out diagrammatically, but the heating contractor must work out details for piping, equipment connections, controls, etc., which all influence the cost.

To acquire the necessary technical knowledge for this purpose requires everyday participation in this line of work plus constant study to keep up to date. Heating and air conditioning is too complex a subject to treat in a volume of this kind, however, much useful data and information can be gained from manuals published by the National Warm Air Heating and Air Conditioning Association and the Handbook of Air Conditioning, Heating and Ventilating.

Anything appearing in this volume on this involved subject is only the most elementary and approximate—for "roughing" or approximate estimates only.

Boilers are now designed for burning special fuels, such as hard coal, soft coal, oil, gas, etc., and the costs vary with boiler sizes, accessories, such as domestic hot water heaters, thermostatic controls, etc.

The ordinary cast iron radiators standing in the room are practically a thing of the past in modern heating systems and concealed convection type radiators or baseboard radiation are now used. These are all items that affect costs.

Copper piping is now used for both heating and plumbing and the cost of this work depends to a large extent upon the experience of the contractor installing same. Mechanics familiar with sweating joints and installing copper piping can install this work rapidly, while those who are not accustomed to its use, will spend considerable time on it.

For the above reasons, the estimator should be familiar with the requirements of the trade in order to prepare intelligent estimates.

Determining Heating Loads.—The first step in designing and estimating heating work is to determine the maximum heating load. For most residential work, the maximum heating load is the total heat loss of the structure figured at design temperatures. For commercial and industrial structures, special purpose heating loads and pick-up loads may be required which must be added to the total building heat loss to obtain maximum heating load.

Heating loads and heat losses are invariably expressed in BTU per hour. A BTU (British Thermal Unit) is the quantity of heat required to raise the temperature of 1 lb. of water 1 degree F.

Building heat losses vary considerably depending upon climatic location of job, design temperatures, exposure, building size, architectural design, purpose of structure, construction materials used, quality of construction workmanship and other factors.

Heat losses should be figured separately for each room so that the proper amount of radiation may be provided for comfort in all areas. Space limitations in this volume do not permit giving detailed information and data on figuring building heat losses and anything less would be misleading. Complete information and data on this subject are contained in the manuals and guide previously mentioned.

FORCED WARM AIR HEATING SYSTEMS

Forced warm air heating is the most widely used residential heating method in use at the present time. Generally speaking, the forced warm air heating method differs from the old gravity type by using blower equipment to circulate the air in the system.

It is practically impossible for the average general estimator to compute the cost of a modern forced warm air heating system, unless he has a working knowledge of this subject and is able to calculate building heat losses and design systems which will satisfy heating requirements under design conditions. In addition, the subject has become so complex it cannot be covered in a volume of this kind so as to provide adequate information for the preparation of a cost estimate, other than a rough approximation to be used for preliminary purposes only. Always obtain firm quotations from reputable warm air heating contractors before submitting bids on jobs containing this work.

Winter Air Conditioning Systems.—Forced warm air heating systems which are equipped with automatic humidifying devices

and air filters are popularly known as Winter Air Conditioning Systems. Most forced air installations are of this type.

Each system consists of a direct fired heating unit, a blower, a system of warm air ducts and return air duct system. Air filters are located in the return air duct system just ahead of the blower—humidifying equipment is placed in the warm air plenum chamber over the furnace unit. Air cooling equipment may be added to make this a year 'round system.

The unit may be gas, oil or coal fired. Gas or oil fired units designed for that particular fuel operate at high efficiency, although satisfactory, if less efficient results may be obtained through the use of conversion burners installed in units primarily designed for solid fuel.

Thermostatic control of heating apparatus is highly desirable and invariably used. Automatic controls vary the supply of heat in accordance with demand set up by a thermostat located in the living portion of the home. Actuated by limit controls, the blower commences operation automatically when the heated air in the generating unit has reached a pre-determined temperature and cuts out after the source of heat has been shut down and the temperature in the bonnet dropped to a pre-determined point.

Design of air conveying systems of this kind presents an engineering problem which can only be solved with a reasonable degree of accuracy by a competent designer. The heat loss of the building, room by room, is established and the volume of heated and conditioned air required for indoor comfort establishes data from which a duct system can be designed with due regard for velocities, static pressures and delivery temperatures.

Items to be Included in the Estimate.—Costs vary considerably and methods of estimating also differ, but every estimate for a winter air conditioning system should include the following items:

1. Cartage of material and equipment from shop to job.
2. Winter air conditioning unit, complete with humidifier, air filters and controls.
3. Labor assembling and setting up unit.
4. Oil storage tank installation, including fill and vent piping, oil booster pump if required, oil gauge, piping to unit, oil filter, etc., for oil fired units, or—piping for gas fired units.
5. Installation of smoke pipe, fittings and accessories.
6. Warm air and return air plenum chambers.
7. Warm air and return air duct systems.

8. Diffusers, registers, intakes, grilles, etc.
9. Special insulation.
0. Electrical work.
1. Labor starting plant in operation and balancing system.
2. Service allowance.
3. Miscellaneous costs.
4. Overhead and profit.

Cartage.—The cost of trucking material and equipment from hop to job will vary depending upon size of job and distance rom shop. An allowance of $25.00 to $50.00 should cover this item n most small jobs.

Cost of Winter Air Conditioning Units.—Sizes, capacities and prices of units vary with the different manufacturers, but the ollowing listings are representative of models available for esidential use.

Approximate Net Prices of Winter Air Conditioning Units, Complete with Automatic Controls, Humidifier and Air Filters

Bonnet Rating BTU per Hr.	Register Rating BTU per Hr.	Net Price
	Gas Fired Units	
60,000	48,000	$285.00
76,000	60,800	340.00
90,000	72,000	355.00
108,000	86,400	390.00
120,000	96,000	420.00
150,000	120,000	510.00
180.000	144,000	550.00
	Oil Fired Units	
84,000	71,400	420.00
112,000	95,200	470.00
140,000	119,000	540.00
175,000	148,750	670.00
210,000	178,500	700.00

Assembling and Setting up Unit.—Most gas fired units can be assembled and set up by a sheet metal worker and a helper n 3 to 4 hours. For an oil fired unit, figure 4 to 5 hours for his work.

Oil Storage Tanks.—Common practice for oil storage tanks s the use of one or two inside storage tanks with a capacity of 275 gals. each. Occasionally outside buried tanks of 550 or

1,000 gallon capacity are used. On a contract basis, these tanks installed, including all piping, cost as follows:

1—275 gallon inside tank	$ 85.00
2—275 gallon inside tanks	140.00
1—550 gallon outside tank	165.00
1—1,000 gallon outside tank	300.00

In the use of an outside tank a basement wall type pump costing from $50.00 to $70.00, must be used with some types of burner equipment.

Gas Piping.—For average installations, an allowance of $40.00 to $60.00 should cover cost of material and labor for piping gas to unit.

Smoke Pipe.—Material and labor for smoke pipe connection from unit to flue should cost $20.00 to $30.00 for gas fired units and $25.00 to $30.00 for oil fired units.

Plenum Chambers.—Plenum chambers must be fabricated to order in the shop and are usually made from light ga. galvanized steel. They are mounted on top of furnace and serve to connect the warm air and return air duct systems to the unit. Two plenum chambers are required for each installation.

An allowance of $25.00 to $35.00 will usually cover the cost of material and labor required to fabricate and install plenum chambers.

Warm Air and Return Air Duct Systems.—The cost of duct work will vary with the size of job and type of distribution.

Under ordinary conditions, the warm air heating contractor will measure and list each type and size of duct, fitting and accessory. These quantities are priced for material and then an estimate is made of labor required for installation. This is a lengthy operation and requires an experienced heating man.

When pressed for time, the duct system cost may be approximated on an outlet basis, using a unit price which covers both material and labor. For ordinary installations, the following costs per outlet are about average where sheet metal workers' wages are from $5.50 to $5.70 per hr.:

Type of System	Cost per Outlet
Conventional system—warm air outlets located on inside walls.	
1st floor outlets	$31.00 to $36.00
2nd floor outlets	45.00 to 49.00
Capped stacks	14.00 to 18.00

Type of System	Cost per Outlet
adial perimeter system in small 1-sty. buildings with basement or crawl space.	
Low velocity—6" to 8" dia. ducts	$35.00 to $45.00
High velocity—4" and 5" dia. ducts	29.00 to 32.00
Large central return air duct	40.00 to 45.00
adial perimeter system in small 1-sty. basementless buildings.	
Galv. steel sheet metal pipe and fittings	$40.00 to $45.00
Fiber duct with galv. steel fittings	40.00 to 45.00
Cement asbestos pipe and fittings	48.00 to 52.00
runk and branch perimeter system in medium-size, 1-sty. buildings with basement or crawl space.	
Std., galv. steel, rectangular ducts	48.00 to 52.00

Add for diffusers, registers, intakes, special insulation, etc. xcavation, backfill and concrete encasement where required, ot included.

Diffusers, Registers and Intakes.—Diffusers and registers enerally used are of pressed steel construction, with prime oat finish, are fully adjustable and are available in floor, base-oard or wall types. Return air intakes are of same construction nd finish, but are non-adjustable.

Floor type diffusers cost $3.00 to $4.00 for sizes commonly used. aseboard type diffusers cost $4.00 for 2'-0" lengths and $5.50 for -0" lengths. Wall type registers cost $3.50 to $6.00. Wall type in-ke grilles cost $2.50 to $6.00.

Special Insulation.—Ducts in unexcavated spaces or in un-eated attic spaces, both supply and return, should be insulated ith not less than ½" of adequate insulating material. This aterial is furnished in flexible form and averages 60 to 80 cts. er sq. ft. applied.

Electrical Work.—Custom varies with respect to the supply nd installation of electrical circuit from meter to fused safety witch adjacent to unit. Likewise for the connection of blower otor to 110 volt controls and also for the 22 volt wiring to ermostat when used. Most often the job electrician runs the 0 volt service to the safety switch adjacent to unit. From this oint it is handled as a subcontract under the heating contrac-r and represents a cost of from $30.00 to $60.00 for complete iring installation of all controls and motors.

Labor Starting and Balancing System.—It is customary for he heating contractor to start the plant in operation, test all ontrols and balance the air distribution system. For jobs com-

pleted during summer months, this means a come-back call at the beginning of the heating system.

Labor costs for this work will run $30.00 to $60.00, depending upon size of job.

Service Allowance.—Most jobs carry a 1-year free service warranty and an allowance should be included in the estimate to cover this contingency. Average costs for service during the first year of operation are $25.00 for gas fired and $35.00 for oil fired systems.

Miscellaneous Costs.—Under miscellaneous costs are classified such items as federal tax, sales tax, permits for oil burner or for installation, if required.

Overhead and Profit.—Most heating contractors would like to add 10 percent for overhead and 10 percent for profit to their estimates, but in the present competitive market, the majority of jobs are being quoted with a straight 10 percent mark-up.

Approximate Cost of a Complete System Installed.—Based on installations in residences of ordinary construction, located in the larger cities, the cost of average winter air conditioning systems ranges as follows for gas fired units. For oil fired units, add 10 to 15 percent.

Floor Area Sq. Ft.	Heat Loss BTU per Hr.	Price for Complete Gas Fired Installation
Conventional Systems, 1-Sty. Buildings with Basements or Crawl Space.		
1,000	65,000	$ 825.00 to $ 950.00
1,500	80,000	1,150.00 to 1,325.00
2,000	100,000	1,450.00 to 1,650.00
Conventional Systems, 2-Sty. Buildings with Basements.		
1,500	75,000	1,200.00 to 1,400.00
2,000	90,000	1,600.00 to 1,850.00
Perimeter Systems, 1-Sty. Buildings with Basements or Crawl Space.		
1,000	65,000	825.00 to 950.00
1,500	80,000	1,200.00 to 1,400.00
2,000	100,000	1,700.00 to 1,900.00
Perimeter Systems, 1-Sty. Basementless Buildings.		
1,000	65,000	825.00 to 950.00
1,500	80,000	1,150.00 to 1,325.00

The above prices are for individual jobs. For multiple housing projects, where large numbers of similar dwelling units are involved, much better prices may be obtained.

As previously mentioned, in this industry, equipment, design and practices vary greatly even in localized areas. No safe guide may be set down for general use. So much depends upon correct design, proven equipment and experienced installation

at it behooves the buyer to carefully investigate all of these ms before awarding a contract for this important part of e building.

SUMMER AIR CONDITIONING

Residential summer air conditioning is now available to the neral public at a price the average home owner can afford. his applies to both existing homes and new homes under con- ruction and is especially true where forced warm air heating is ed, as the same air distribution duct system can be utilized for th heating and cooling. Various warm air heating equipment anufacturers make cooling units for this purpose and installa- on work is usually done by heating contractors.

The function of summer air conditioning equipment is the verse of winter air conditioning—circulating air is cooled d de-humidified—but design problems are similar, although ore complex. A basic requirement for designing a cooling stem is calculating the total cooling load or total heat which ust be removed from the structure to achieve a pre-determined side temperature and humidity under design conditions. Heat in calculations are much more involved than those for heat sses as many additional factors must be considered, such as n effect on roof, wall and glass areas; internal heat gains om human occupancy, cooking, lighting, appliances, etc. and tent heat energy involved in de-humidification. This is a job r an expert.

Heat gain calculations are always expressed in B.T.U. per our. Cooling equipment capacities are usually stated per ton of frigeration. A ton of refrigeration will remove heat at the te of 12,000 BTU per hr. In a 24-hr period, this is equivalent the heat required to melt a ton of ice. With water-cooled mpression refrigeration equipment, one horsepower usually uals about one ton of cooling capacity.

Types of Cooling Equipment for Residential Use.—There are veral types of cooling units available and in popular use for sidential summer air conditioning. In general, equipment may classified as water-cooled or air-cooled, with each type avail- ble for several methods of application.

One method employs a remotely located condensing unit, with frigerant lines connected to a cooling coil installed in the arm air plenum chamber of a forced warm air heating sys- m. This method uses the heating system blower and ducts r air distribution.

Another method uses a self-contained unit, with the con- enser, cooling coil and blower combined in one cabinet. This

type may be cut in to the heating ducts, or may have its own duct system where hot water or steam heat is used.

Net Prices of Remote System Cooling Units.—Approximate prices are for units factory assembled with heating and cooling thermostat included. No pipe, duct materials or blower assembly included.

Capacity Tons	Rating BTU per Hr.	Net Price Water cooled	Net Price Air-cooled
2	24,000	$600.00	$ 400.00
3	36,000	700.00	600.00
5	60,000	900.00	1,000.00

Labor Installing Cooling Units.—Labor costs for installing cooling units vary with the size and type of unit.

For a remote, water-cooled installation, piped to an existing water supply and drainage system, two mechanics should install the unit complete in 32 to 40 hours. For self-contained, water-cooled units, where heating ducts may be used for air distribution, add about 2 hours for each man.

For a remote air-cooled installation, two mechanics should install the unit complete in 16 to 20 hours. For self-contained, air-cooled units, where heating ducts may be used, add about 4 hours for each man.

Where a complete air circulation duct system is required, figure same as previously given for winter air conditioning systems.

Approximate Cost of Complete Cooling Unit Installation.—Based on conditions of average difficulty, complete residential cooling unit installations should cost approximately as follows:

Capacity Tons	Rating BTU per Hr.	Price for Complete Installation
	Remote, Water-cooled System	
2	24,000	$ 900.00 to $1,000.00
3	36,000	1,050.00 to 1,200.00
	Remote, Air-cooled System	
2	24,000	1,150.00 to 1,300.00
3	36,000	1,300.00 to 1,450.00
5	60,000	1,600.00 to 1,800.00
	Self-contained, Water-cooled System	
2	24,000	1,000.00 to 1,100.00
3	36,000	1,175.00 to 1,325.00
	Self-contained, Air-cooled System	
2	24,000	1,300.00 to 1,450.00
3	36,000	1,450.00 to 1,600.00
5	60,000	1,825.00 to 2,000.00

Table Giving Cubical Contents of Various Size Rooms

Height of Ceilings	SIZE OF ROOMS IN FEET (Use Nearest Size)														
	3x16½	4x18¾	5x20	6x21	7x21½	8x22	9x22	10x22½	11x23	12x23	13x23	14x23	15x23	16x23½	17x23½
	4x12½	5x15	6x16½	7x18	8x18¾	9x19½	10x20	11x20½	12x21	13x21	14x21½	15x22	16x22	17x22	18x22½
	5x10	6x12½	7x14½	8x15½	9x16½	10x17½	11x18	12x18¾	13x19	14x20	15x20	16x20	17x20½	18x21½	19x21½
	6x 8½	7x10½	8x12½	9x14	10x15	11x16	12x16½	13x17½	14x18	15x18	16x18½	17x19½	18x19½	19x20½	20x20
	7x 7	8x 9½	9x11	10x12½	11x13½	12x14½	13x15½	14x16	15x16½	16x17½	17x17½	18x18	19x18	20x19	21x19
	8x 6½	9x 8½	10x10	11x11½	12x12½	13x13½	14x14½	15x15	16x15	17x16	18x16	19x17	20x17	21x18	22x18
	AIR SPACE IN ROOMS IN CUBIC FEET														
8	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
8½	425	640	850	1060	1275	1490	1700	1910	2125	2340	2550	2760	2975	3190	3400
9	450	675	900	1125	1350	1575	1800	2020	2250	2480	2700	2920	3150	3370	3600
9½	475	715	950	1190	1425	1660	1900	2140	2375	2610	2850	3090	3325	3560	3800
10	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000
10½	525	790	1050	1310	1575	1840	2100	2360	2625	2890	3150	3420	3675	3940	4200
11	550	825	1100	1375	1650	1925	2200	2480	2750	3030	3300	3580	3850	4130	4400
11½	575	860	1150	1440	1725	2010	2300	2600	2875	3170	3450	3740	4025	4310	4600
12	600	900	1200	1500	1800	2100	2400	2700	3000	3300	3600	3900	4200	4500	4800
12½	625	940	1250	1560	1875	2190	2500	2820	3125	3440	3750	4070	4375	4690	5000
13	650	980	1300	1625	1950	2280	2600	2930	3250	3580	3900	4240	4550	4880	5200
13½	675	1010	1350	1690	2025	2360	2700	3040	3375	3720	4050	4400	4725	5060	5400
14	700	1050	1400	1750	2100	2450	2800	3160	3500	3860	4200	4550	4900	5250	5600
14½	725	1085	1450	1810	2175	2540	2900	3260	3625	4000	4350	4700	5075	5440	5800
15	750	1125	1500	1880	2250	2620	3000	3380	3750	4140	4500	4880	5250	5625	6000

Courtesy American Radiator Co.

Room Size Air Conditioning Units.—The cost of portable room size air conditioning units vary according to size, ranging from ½-Hp., which cools room areas up to 400 sq. ft., to 2-Hp. for spaces up to 1,200 sq. ft.

All models are for window installation and include automatic thermostat controls.

Net prices run from $175.00 for a ½-Hp. unit to $350.00 for 2-Hp. units.

If electric wiring is necessary, add extra for installation.

For quick approximations of air cooling costs cooling units can be estimated at from $900.00 to $1,250.00 per ton depending on the ductwork, job conditions, types of grilles, etc. 12,000 BTUs requires one ton of air cooling. The following table will give an approximation of final requirements:

Type Of Space	BTU
Large Stores	40
Offices	45
Specialty Shops	50-70
Bars	80
Restaurants	100-120

STEAM AND HOT WATER HEATING

Because of different conditions surrounding the installation of heating apparatus, it is impossible to give any set rule that can be accepted, without modification, for all kinds of buildings to be heated. It is necessary to take into consideration all of the conditions in and around any building, and additions or deductions made to suit the requirements, no matter what rule may be used for figuring.

Methods of Computing Heating.—The most advanced method of figuring heating and the one that is generally used by heating engineers is the BTU Method. This method is based on replacing the heat loss through exposed walls, doors and windows, floors, ceilings, etc., and uses so many factors, based on the type of construction that it is impossible to go into detail in a book of this kind, as intricate and elaborate formulas are used for both warm air, steam and hot water heating. In fact, if the entire subject of heating was thoroughly covered, it would require a book as large as this one. For this reason only approximates can be treated in this chapter.

Flow Control Hot Water Heating Systems.—This method of ot water heating has largely superseded the older gravity or pen" type of hot water heating system. It is a complete com- ned automatic water heating and domestic water supply sys- m for year 'round use. It's major advantages are instantaneous eating response, high efficiency, fuel economy and completely utomatic operation.

The flow control valve makes the boiler a reservoir of high mperature water, in that it prevents circulation through the stem when heat is not required. A circulator or pump attached the main near the boiler forces this hot water through the ains the instant the room thermostat calls for heat. When e thermostat is satisfied the circulator ceases to operate and e flow control valve stops all circulation of hot water, thus reventing overheating and needless heat losses.

The flow control hot water heating system requires approxi- ately 20 percent more radiation than is figured for steam heat. he mains are smaller reducing the cost of pipe, fittings and labor nstalling same.

All in all, a flow control hot water heating system costs a ifle less than the older gravity systems requiring large radia- rs and piping.

A gravity hot water heating system can be converted into a ow control system at a nominal expense.

Cost of Special Fittings for Flow Control Hot Water Heating ystems.—The cost of fittings will vary with the amount of adiation in the job and whether or not a complete flow control ystem is used or merely a flow control valve and a circulating ump.

Where only the flow control valve and water circulating pump re used, the costs for the special equipment will run as follows ased on the amount of radiation in the job.

Capacities and Prices of Flo-Control Valves

alve ize	Radiation Capacity in Square Feet 150 BTU	200 BTU	240 BTU	Weight Pounds	Price Each
"	354	265	221	5	$ 6.80
¼"	786	590	492	5	7.60
½"	1170	875	730	10	9.50
"	2140	1610	1340	21	11.00
½"	3680	2750	2300	33	16.00
"	6660	5000	4160	42	28.00
"	14000	10000	8750	57	72.00

The above prices are net to the heating contractor.

Sizes and Prices of Water Circulators or Booster Pumps

Recommended for use on modern forced circulation systems or for improving gravity hot water systems.

Size Inches	Motor H.P.	Dely. Gals. per Min.	Direct Radiation Capacity in Sq. Ft. 150 BTU	200 BTU	240 BTU	Price Each Iron Body	All Bronze
1	1/12	31	750	562	469	$49.10	$ 69.16
1¼	1/12	33	1000	750	675	$49.10	$ 69.16
1½	1/12	33	1000	750	675	$49.10	$ 69.16
2	⅙	75	3500	2625	2187	74.25	115.04
2½	¼	120	4500	3375	2820	98.06	167.52
3	¼	120	4500	3375	2820	99.44	169.94

Above prices are for horizontal type pumps for installation in vertical lines and are net to the heating contractor.

Sizes and Prices of Relief Valves

A.S.M.E. Capacity at 30 lbs. in BTU per Hr.	Size Inches	Net Price
175,000	¾	$ 5.67
250,000	¾	7.95
350,000	¾	8.10
480,000	¾	8.50
750,000	1	9.95
1,050,000	1¼	14.50

Sizes and Prices of Air Control Boiler and Tank Fittings

Air control fittings are used for the purpose of removing air from a hot water heating system and preventing its return.

Air control boiler fittings consist of a tube inserted into a T-shaped fitting. The tube, in effect, extends the supply main down into the boiler water, thus preventing air, which has accumulated at the top of the boiler, from rising into the piping and heating units. This air flows around the tube, up into the T fitting and then to the pipe leading to the air control tank fitting.

The air control tank fittings provide two separate passages—one through which air can flow to the top of the tank, and the other for the water displaced by the air to flow back into the pipe connections to the system.

Table Giving Number of Square Feet of Surface in Exposed Walls of Various Lengths and Heights

Height of Ceiling	RUNNING FEET OF EXPOSED WALL WITHOUT REGARD TO WINDOW OPENINGS																		
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160	168	176	184	192
8½	51	60	68	76	85	94	102	110	119	127	136	145	153	162	170	178	187	195	204
9	54	63	72	81	90	99	108	117	126	135	144	153	162	171	180	189	198	207	216
9½	57	66	76	86	95	105	114	123	133	142	152	161	171	181	190	200	209	218	228
10	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
10½	63	73	84	94	105	115	126	136	147	157	168	178	189	199	210	220	231	242	252
11	66	77	88	99	110	121	132	143	154	165	176	187	198	209	220	231	242	253	264
11½	69	80	92	104	115	126	138	149	161	172	184	195	207	218	230	241	253	265	276
12	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288
12½	75	87	100	112	125	137	150	162	175	187	200	212	225	238	250	262	275	287	300
13	78	91	104	117	130	143	156	169	181	195	208	221	234	247	260	273	286	299	312
14	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280	294	308	322	336
Height of Ceiling	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
8	200	208	216	224	232	240	248	256	264	272	280	288	296	304	312	320	328	336	344
8½	212	221	230	238	246	255	263	272	280	289	298	306	315	323	332	340	349	357	366
9	225	234	243	252	261	270	279	288	297	306	315	324	333	342	351	360	369	378	387
9½	237	247	256	266	275	285	294	304	313	323	332	342	351	361	370	380	389	399	408
10	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430
10½	262	273	283	294	305	315	325	336	346	357	367	378	388	399	409	420	430	441	451
11	275	286	297	308	319	330	341	352	363	374	385	396	407	418	429	440	451	462	473
11½	287	299	310	322	333	345	356	368	379	391	403	414	426	437	449	460	471	483	494
12	300	312	324	336	348	360	372	384	396	408	420	432	444	456	468	480	492	504	516
12½	312	325	337	350	362	375	387	400	412	425	437	450	462	475	487	500	512	525	537
13	325	338	351	364	377	390	403	416	429	442	455	468	481	494	507	520	533	546	559
14	350	364	378	392	406	420	434	448	462	476	490	504	518	532	546	560	574	588	602

Courtesy American Radiator Co.

Boiler Control Fittings			Tank Control Fittings		
Size Inches	For Valve or Supply Main	Price Each	Size Inches	For Tank Diameters Inches	Price Each
1	1	$ 7.32	9	9	$8.25
1¼	1¼	7.87	12	12 or 13	8.25
1½	1½	8.42	16	16	8.25
2	2	8.97	18	18	8.25
2½	2½	9.52	24	24	8.25
3	3	11.83			

Coils for Heating Water.—Where coils are inserted in the boiler for heating water for domestic purposes, the size of the boiler should be increased, figuring each gallon of water tank capacity as equivalent to 1 sq. ft. of steam radiation or 2 sq. ft. of hot water radiation. For example, a 30-gal. tank is equivalent to 30 sq. ft. of steam or 60 sq. ft. of hot water radiation.

Rule for Computing Boiler Sizes.—After the total number of square feet of radiation or total heat loss in BTU per hour has been obtained, the size of the boiler should be computed.

Practically all boiler manufacturers rate their boilers, giving maximum heat output under full drive and also the recommended load, which represents the attached load, including piping, which may be placed on the boiler in accordance with accepted installation standards for economical operation.

Regarding Steam Boiler Installation.—It is recommended on all installations of steam boilers that drain valves be placed on the returns and that the condensation from such returns be discharged into the sewer for a period of 3 days to one week after starting fire, thereby clearing system of grease and dirt. At the end of this period the boiler should be thoroughly washed and blown out.

Boiler Capacity.—Boiler output is defined as the number of sq. ft. of standard direct column radiation or its equivalent in BTU, which a boiler will supply at its outlet in one hour, under standard conditions.

240 BTU represents one sq. ft. of standard direct column steam radiation.

150 BTU represents one sq. ft. of standard direct column water radiation.

Boiler Horsepower.—One boiler horsepower is defined as the evaporation of 34½ lbs. of water per hour from a feed water temperature of 212 degrees into steam at 212 degrees. This is equal to 34.5x970.4=33478.8 B.t.u. per hour.

One boiler horsepower is equal therefore to $\frac{33478.8}{240}$ = 139 sq. ft. of steam radiation.

Table Giving Number of Square Feet of Area in Window Openings of Various Sizes

Width Glass	Width of Open'g	Height Glass	18"	20"	22"	24"	26"	28"	30"	32"	34"	36"	38"	40"	42"	44"	46"	48"	50"	52"	54"
In.	Ft. In.	Height Open'g	3'-6"	3'-10"	4'-2"	4'-6"	4'-10"	5'-2"	5'-6"	5'-10"	6'-2"	6'-6"	6'-10"	7'-2"	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"
16	1- 8	Standard Sizes of Two-Light Windows.	5.8	6.4	7.0	7.5	8.0	8.6	9 2	9.7	10.3	10.8	11 4	11.9	12.5	13.0	13 6	14.2	14.7	15.2	15.8
18	1-10		6.4	7.0	7.6	8 2	8.9	9.5	10.1	10.7	11.3	11.9	12.5	13.1	13.7	14.3	15.0	15.6	16.2	16.8	17.4
20	2- 0		7.0	7.7	8.3	9.0	9.7	10.3	11.0	11.7	12.3	13.0	13.6	14.3	15.0	15.6	16.3	17.0	17.7	18.3	19.0
22	2- 2		7.6	8.3	9.0	9 7	10.5	11.2	11 9	12.6	13 4	14.0	14 7	15.5	16 2	17.0	17.7	18.4	19.2	19.8	20.6
24	2- 4		8.2	8.9	9.7	10 5	11.3	12.0	12.8	13.6	14.4	15.1	15.9	16.7	17.4	18.2	19.0	19.8	20.6	21.4	22.2
26	2- 6		8.7	9 6	10 4	11.2	12.0	12.8	13.7	14 6	15 4	16 2	17.1	17.9	18.7	19.5	20.4	21.2	22.0	23.0	23.8
28	2- 8		9 3	10.2	11.1	12.0	12.9	13.8	14.7	15 5	16.4	17.3	18.2	19.1	20.0	20.8	21.8	22.6	23.5	24.4	25.3
30	2-10		10.0	10.8	11.8	12.8	13.7	14.6	15.6	16.5	17.5	18.4	19.3	20.3	21.2	22.2	23.2	24.0	25.0	26.0	27.0
32	3- 0		10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	26.5	27.5	28.5
34	3- 2		11.0	12.1	13.2	14.3	15.3	16.4	17.4	18.5	19.5	20.6	21.6	22.6	23.7	24.8	25.8	27.0	28.0	29.0	30.0
36	3- 4		11.7	12.8	13 9	15.0	16.1	17.2	18.3	19.5	20.5	21.6	22 8	23.8	25.0	26.1	27.2	28.3	29.4	30.5	31.7
38	3- 6		12.2	13.4	14.6	15.8	16.9	18.0	19.2	20.4	21.6	22.7	24.0	25.0	26.2	27.4	28.6	29.8	31.0	32.1	33.2
40	3- 8		12.8	14.0	15.3	16.5	17.7	18.9	20.1	21.4	22.6	23.8	25.1	26.2	27.4	28.7	30.0	31.2	32.4	33.6	34.9
42	3-10		13.4	14.7	16.0	17.3	18.5	19.8	21.0	22.4	23.6	24.9	26.2	27.4	28.6	30.0	31.3	32.6	33.8	35.0	36.4
44	4- 0		14.0	15 3	16.7	18.0	19.3	20.7	22.0	23.4	24.6	26.0	27.3	28.6	30.0	31.3	32.6	34.0	35 3	36.5	38.0
46	4- 2		14.6	16.0	17.4	18.8	20.1	21.5	23.0	24.4	25.6	27.1	28.4	29.8	31.2	32.6	34.0	35.5	36.8	38.2	39.6
48	4- 4		15.2	16.6	18.0	19.5	20.9	22.4	23.8	25.3	26.7	28 1	29.5	31.0	32.4	34.0	35.4	36.8	38.3	39.6	41.0
50	4- 6		15.7	17.2	18.7	20 3	21.8	23.2	24.8	26.2	27.7	29.2	30.7	32.2	33.7	35.2	36.7	38.2	39.7	41.2	42.6
52	4- 8		16.3	17.9	19.4	21.0	22.5	24.0	25.6	27.2	28.7	30.3	31 8	33.4	35.0	36.5	38.0	39.6	41.2	42.7	44.2
54	4-10		16.9	18.5	20.1	21.8	23.4	25.0	26.6	28.2	29.8	31.4	32.9	34.6	36.2	37.8	39.5	41.0	42.7	44.3	46.0
56	5- 0		17.5	19.3	20.8	22.5	24.2	25.8	27.5	29.0	30.8	32.5	34.0	35.8	37.5	39.8	40.8	42.5	44.2	46.0	47.5

Courtesy American Radiator Co.

Note that boiler horsepower is not derived from engine horsepower.

1 horsepower hour = 2545 BTU.

To find the BTU output per hour of a steam boiler, multiply the output in sq. ft. by 240.

To find the BTU output per hour of a water boiler, multiply the output in sq. ft. by 150.

To find the output in sq. ft. of steam radiation, divide the output in BTU per hour by 240.

To find the output in sq. ft. of water radiation, divide the output in BTU per hour by 150.

Estimating Pipe and Fittings.—To prepare an intelligent estimate on the cost of any heating plant, the entire job should be laid out using the quantity of pipe of each size required; connections, such as elbows, tees, nipples, valves, etc., should all be figured separately. This requires considerable labor and a man must thoroughly understand his business to figure with any degree of accuracy.

When estimating the quantities of piping required for any heating plant, the risers, mains and returns must be figured, together with all connections to and from the boilers. These will vary according to the system used and the type of building.

A one-pipe steam heating system should have the highest point in the main directly over the boiler, and from this point it pitches down around the circuit until it drops to the floor or enters the boiler. The more pitch the better, but there should be at least one inch in 20 feet. The lowest point in the steam main, where it drops to enter the boiler or to the floor, should not be less than 14 inches above the water line of boiler and the more the better.

Branches for radiators should be taken from top of main, using a nipple and elbow or a nipple and a 45-degree ell, and should pitch up to the radiator.

Connections for steam should never be taken from side of main, as this will cause water hammer and syphoning of the water of condensation in the steam main into the radiator.

Each radiator should be supplied with a good disc radiator valve and a good automatic air valve, and each return main should also have an automatic air valve where it drops to enter boiler.

If branches are longer than 8 or 10 feet, they should be one size larger than the upright connecting pipes. Where mains drop to floor, a pipe two sizes smaller can be used to return to boiler. Risers for either steam or water should be plumb and

straight and if exposed in a room, and it is necessary to use couplings on same, the couplings should be at a uniform height from floor.

The valve on a steam radiator should be either wide open or tightly closed to prevent radiator filling with water.

In a two-pipe gravity hot water heating system the highest return rises from boiler to radiator, the lowest point being at the boiler and the highest point at the end of the main. These pipes may be reduced as the branches are taken off, care being taken not to reduce too rapidly. Each radiator should be fitted with a hot water radiator valve, union elbow and a compression air valve. All pipes should be well supported, so that no pockets or depressions will occur to retard or trap the circulation. All mains, both for steam and hot water, should run about 4 feet from wall to allow for expansion.

Practically all hot water heating systems installed today are flow control systems where the hot water is circulated from the boiler through the mains and pipes, using a circulating or booster pump. When this method is used, the size of the mains can be greatly reduced, as will be noted from the following table. With the water being circulated through the system at 30 to 120 gallons a minute, it is very much faster than the old gravity systems. Also the radiators may be placed above or below the boiler level, as desired.

Sizes of Pipes.—When estimating steam heating, using a rule of thumb method, the size of the main may be determined by taking the total amount of direct radiation to which add 25 percent for piping and from this total extract the square root, dividing same by 10, which gives the size of the main to use. This is for one pipe work.

For two pipe work one size less is sufficient and the return can be one or two sizes less than the supply. A steam main should not decrease in size but very little according to the area of its branches.

An example of the above method is as follows: A job contains 400 feet of direct steam radiation. By adding 25 percent for piping, the result is 500 square feet. Extracting the square root of 500, gives 22.4. Divide 22.4 by 10 equals 2.24 or it will require a 2½-inch steam main.

Table Giving Number of Square Feet of Radiation in Exposed Heating Pipes of Various Sizes and Lengths

Length of Pipe	Size of Pipe											
	¼	1	1¼	1½	2	2½	3	4	5	6	7	8
1	.275	346	.434	494	.622	.753	.916	1.175	1.455	1.739	1.996	2.257
2	.5	.7	.9	1.	1.2	1.5	1.8	2.4	2.9	3.5	4.	4.5
3	.8	1.	1.3	1.5	1.9	2.3	2.7	3.5	4.4	5.2	6.	6.8
4	1 1	1.4	1.7	2.	2.5	3.	3.6	4.7	5.8	7.	8.	9.
5	1.4	1.7	2 2	2.4	3.1	3.8	4.6	5.8	7.3	7.7	10.	11.3
6	1 6	2.1	2.6	2.9	3.7	4.5	5.5	7.	8.7	10.5	12.	13.5
7	1.9	2.4	3.	3.4	4.4	5.3	6.4	8.2	10 2	12.1	14.	15.8
8	2.2	2.8	3.5	3.9	5.	6.	7.3	9.4	11 6	13 9	16.	18.
9	2.5	3 1	3.9	4.4	5.6	6.8	8.2	10.6	13.1	15.7	18.	20.3
10	2.7	3.5	4 3	4.9	6.2	7.5	9.1	11.8	14.6	17.4	20.	22.6
11	3.	3.8	4.8	5 4	6.8	8.3	10.	12.9	16.	19.1	22.	24.9
12	3.3	4.1	5.2	5.9	7.5	9.	11.	14.1	17.4	20.9	24.	27.1
13	3 6	4.5	5.6	6.4	8.1	9.8	11.9	15.3	18.9	22.6	26.	29.4
14	3.8	4.8	6.1	6.9	8.7	10.5	12.8	16.5	20.3	24.3	28.	31.6
15	4.1	5.2	6.5	7.4	9.3	11.3	13.7	17.6	21.8	26.1	30.	33.9
16	4.4	5.5	6.9	7.9	10.	12.	14.6	18.8	23.2	27.8	32.	36.1
17	4.7	5 9	7.4	8 4	10.6	12.8	15.5	20.	24.7	29.5	34.	38.4
18	5.	6.2	7 8	8 9	11.2	13.5	16.5	21.2	26.2	31.3	36.	40.6
19	5.2	6.6	8.3	9.4	11 8	14.3	17.4	22.3	27.6	33.1	38.	42.9
20	5.5	6.9	8.7	9.9	12.5	15.	18.3	23.5	29.1	34.8	40.	45.2
21	5 8	7.3	9.1	10.4	13.	15.8	19.2	24 7	30.5	36.5	42.	47.4
22	6.	7.6	9.6	10.9	13.7	16.5	20.2	25.9	32.	38.3	44.	49.7
23	6.3	8.	10.	11.3	14.3	17.3	21.1	27.	33.5	40.	46.	52.
24	6.6	8.3	10.4	11.9	14.9	18.	22.	28.2	34.9	41.7	48.	54.2
25	6.9	8 6	10.9	12.3	15.6	18.8	22.9	29.3	36.3	43.5	50.	56.4
26	7.1	9.	11.3	12.8	16.2	19.5	23.8	30.5	37.8	45.2	52.	58.6
27	7.4	9.4	11.7	13.3	16.8	20.3	24.7	31.7	39.3	47.	54.	61.
28	7.7	9.7	12.2	13.8	17.4	21.	25.6	32 9	40.7	48.7	56.	63.2
29	8.	10.	12.6	14.3	18.	21.8	26.6	34.1	42.2	50.4	58.	65.5
30	8 3	10.4	13.	14.8	18.7	22.5	27.5	35.3	43.6	52.1	60.	67.7
31	8 5	10.7	13.5	15.3	19.3	23.3	28.4	36.4	45 1	53.9	62.	70.
32	8.8	11.1	13.9	15.8	19.9	24.1	29.3	37.6	46.5	55.6	64.	72.2
33	9.1	11.4	14.3	16.3	20.5	24.8	30.2	38.8	48.	57.4	66.	74.4
34	9.4	11.7	14.7	16.8	21.2	25.6	31.1	40.	49.5	59.1	68.	76.7
35	9.6	12.1	15.2	17.3	21.8	26.3	32.	41 1	50.9	60.8	70.	79.
36	9.9	12.5	15.6	17 8	22.4	27.	33.	42.3	52.4	62.6	72.	81.3
37	10.2	12.8	16.1	18 3	23.	27.8	33.9	43.5	53.8	64.3	74.	83.5
38	10.5	13.2	16.5	18.8	23.7	28.5	34 8	44.6	55.2	66.	76.	85.8
39	10.7	13.5	16.9	19.3	24.3	29 3	35.7	45 8	56.7	67.8	78.	88.
40	11.	13.8	17.4	19.8	24.9	30 1	36.6	47.	58.2	69.5	80.	90.2
41	11.3	14.2	17.8	20.3	25.5	30.8	37.6	48.2	59.6	71.3	82.	92.5
42	11.5	14.5	18.2	20 8	26.1	31.6	38.5	49.4	61.1	73.	84.	94.8
43	11.8	14.9	18.7	21.3	26.8	32.3	39.4	50.6	62.5	74 8	86.	97.
44	12.1	15.2	19.1	21.8	27.4	33.1	40.3	51.7	64.	76.5	88.	99.3
45	12.4	15 6	19.5	22.2	28.	33.8	41.2	52.9	65.5	78.2	90.	101.6
46	12.7	15.9	20.	22.7	28.6	34 6	42.2	54.	67.	80.	92.	103.8
47	12.9	16.3	20.4	23.2	29.2	35.3	43.	55.2	68.4	81.7	94.	106.
48	13.2	16.6	20.8	23.7	29.9	36.1	43.9	56.4	69.8	83.5	96.	108.4
49	13.5	17.	21.3	24.2	30.5	36.8	44.8	57.6	71.2	85.1	98.	110.5
50	13.8	17.3	21.7	24.7	31.1	37.6	45.8	58.7	72.7	87.	100.	112.8

List of Sizes of Steam Mains.—The following table gives the correct sizes of mains for both one and two pipe steam heating systems, as determined by the above method:

Radiation Square Feet	One-Pipe Work Inches	Two-Pipe Work Inches	Radiation Square Feet	One-Pipe Work Inches	Two-Pipe Work Inches
125	1½	1½x1	2,050	5	4½x4
250	2	1½x1¼	2,500	6	5x4½
400	2½	2 x1½	3,600	7	6x5
650	3	2½x2	5,000	8	7x6
900	3½	3 x2½	6,500	9	8x6
1,250	4	3½x3	8,100	10	9x6
1,600	4½	4 x3½			

List of Sizes for Hot Water Mains.—The following table gives the correct sizes of mains for hot water heating systems:

Radiation Square Feet	Gravity Size Pipe Inches	Forced H.W. 2-Pipe System*	Radiation Square Feet	Gravity Size Pipe Inches	Forced H.W. 2-Pipe System*
75 to 125	1¼	1	950 to 1,200	4	1½
125 to 175	1½	1	1,200 to 1,575	4½	2
175 to 300	2	1	1,575 to 1,975	5	2
300 to 475	2½	1	1,975 to 2,375	5½	2½
475 to 700	3	1¼	2,375 to 2,850	6	2½
700 to 950	3½	1½			

*Based on 200 BTU, emission and circulators having 1,725 r.p.m. motors.

Hot water flow mains may be reduced in size in proportion to the branches taken off. They should, however, have as large areas as the sum of all branches beyond that point. Returns should be same as flows.

Tables of Mains and Branches.—The following table gives the size of mains and the number of branches of different sizes that each main will supply:

Mains	Branches
1 in. will supply	2 ¾ in.
1¼ in. will supply	2 1 in.
1½ in. will supply	2 1¼ in.
2 in. will supply	2 1½ in.
2½ in. will supply	2 1½ in. and 1 1¼ in. or 1 2 in. and 1.1¼ in.
3 in. will supply	1 2½ in. and 1 2 in. or 2 2 in. and 1.1½ in.
3½ in. will supply	2 2½ in. or 1 3 in. or 1 2 in. or 3.2 in.
4 in. will supply	1 3½ in. and 1 2½ in. or 2 3 in. and 4.2 in.
4½ in. will supply	1 3½ in. and 1 3 in. or 1 4 in. and 1.2½ in.
5 in. will supply	1 4 in. and 1 3 in. or 1 4½ in. and 1.2½ in.
6 in. will supply	2 4 in. and 1 3 in. or 4 3 in. or 10.2 in.
7 in. will supply	1 6 in. and 1 4 in. or 3 4 in. and 1.2 in.

Radiator Tappings.—The following is a schedule of tappings or branches required for radiators of different sizes.

Steam — One Pipe

Radiators containing up to 24 sq. ft. of radiation.....1 in.
Radiators containing 24 to 60 ft. of radiation.....1¼ in.
Radiators containing 60 to 100 ft. of radiation.....1½ in.
Radiators containing above 100 ft. of radiation.....2 in.

Gravity Hot Water — Two Pipe

Radiators containing up to 40 ft. of radiation.....1 x1 in.
Radiators containing 40 to 72 ft. of radiation.....1¼x1¼ in.
Radiators containing more than 72 ft. of radiation.....1½x1½ in.

Forced Flow Hot Water

A ¾" branch will take care of most any ordinary size radiator where forced flow is used.

Sizes and Net Prices of Standard Wrought Steel Pipe.
All Weights and Dimensions are Nominal

Size	Price per 100 Lin. Ft. Random T. & C. Black	Galv.	Diameter External	Internal	Weight per Foot Plain Ends	Threads and Couplings	No. of Threads Per In. of Screw
⅛	$ 9.00	$ 12.00	.405	.269	.24	.24	27
¼	12.00	15.00	.540	.364	.42	.42	18
⅜	13.00	16.00	.675	.493	.57	.57	18
½	14.00	16.00	.840	.622	.85	.85	14
¾	18.00	21.00	1.050	.824	1.13	1.13	14
1	25.00	30.00	1.315	1.049	1.68	1.68	11½
1¼	33.00	40.00	1.660	1.380	2.27	2.28	11½
1½	40.00	47.00	1.900	1.610	2.72	2.73	11½
2	54.00	65.00	2.375	2.067	3.65	3.68	11½
2½	85.00	102.00	2.875	2.469	5.79	5.82	8
3	111.00	133.00	3.500	3.068	7.58	7.62	8
3½	149.00	177.00	4.000	3.548	9.11	9.20	8
4	175.00	208.00	4.500	4.026	10.79	10.89	8
5	277.00	332.00	5.563	5.047	14.62	14.81	8
6	346.00	418.00	6.625	6.065	18.97	19.18	8
8	447.00	513.00	8.625	8.071	24.70	25.55	8
8	500.00	571.00	8.625	7.981	28.55	29.35	8
10	620.00	717.00	10.750	10.136	34.24	35.75	8
10	709.00	814.00	10.750	10.020	40.48	41.85	8
12	812.00	937.00	12.750	12.090	43.77	45.45	8
12	896.00	1,023.00	12.750	12.000	49.56	51.15	8

For lengths cut to order, add 15 percent to random length prices.

Sizes and Net Prices of Extra Strong Wrought Steel Pipe

ze	Price per 100 Lin. Ft. Random P.E. Black	Galv.	Diameter External	Internal	Thickness	Weight per Foot Plain Ends
⅛	$ 21.00	$ 26.00	.405	.215	.095	.31
¼	15.00	19.00	.540	.302	.119	.54
⅜	17.00	21.00	.675	.423	.126	.74
½	17.00	21.00	.840	.546	.147	1.09
¾	22.00	27.00	1.050	.742	.154	1.47
	31.00	38.00	1.315	.957	.179	2.17
¼	43.00	53.00	1.660	1.278	.191	3.00
½	52.00	63.00	1.900	1.500	.200	3.63
	71.00	87.00	2.375	1.939	.218	5.02
½	109.00	138.00	2.875	2.323	.276	7.66
	145.00	185.00	3.500	2.900	.300	10.25
½	190.00	246.00	4.000	3.364	.318	12.51
	228.00	295.00	4.500	3.826	.337	14.98
	375.00	...	5.563	4.813	.375	20.78
	496.00	...	6.625	5.761	.432	28.57
	749.00	...	8.625	7.625	.500	43.39
	957.00	...	10.750	9.750	.500	54.74
	1,172.00	...	12.750	11.750	.500	65.42

For lengths cut to order, add 33⅓ percent to random length rices.

et Prices Per 100 Lin. Ft. of Byers Genuine Wrought Iron Pipe

ze	Standard Random T. & C. Black	Galv.	Extra Heavy Random P.E. Black
¼	$ 29.00	$ 33.00	$ 39.00
⅜	32.00	37.00	44.00
½	33.00	37.00	43.00
¾	41.00	48.00	55.00
	59.00	68.00	76.00
¼	80.00	92.00	104.00
½	94.00	107.00	126.00
	127.00	146.00	175.00
½	207.00	236.00	258.00
	271.00	309.00	346.00
½	331.00	373.00	429.00
	381.00	430.00	503.00
	517.00	584.00	704.00
	671.00	758.00	968.00
—25 lb.	897.00	1,004.00	1,430.00
—35 lb.	1,308.00	1,474.00	2,003.00

Net Prices Per 100 Lin. Ft. of Byers Genuine Wrought Iron Pipe—Continued

Size	Standard Random T. & C. Black	Standard Random T. & C. Galv.	Extra Heavy Random P. E. Black	Extra Heavy Random P. E. Galv.
12 —45 lb.	$1,751.00	$1,937.00	$2,617.00	$3,005.00

For lengths cut to order, add to random length prices, 25 per cent for standard pipe and 33⅓ percent for extra heavy pipe.

Size of Expansion Tanks Required for Hot Water Heating Systems

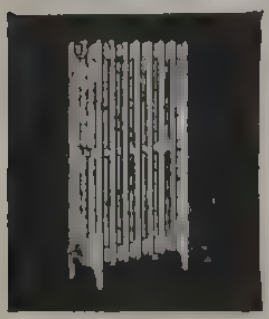
The following table gives the sizes of expansion tanks required for hot water heating systems, complete with trimmings:

Capacity Gallons	Size Inches	Square Feet of Radiation	Price Each with Trimming
15	13⅛x30	350	$13.75
18	13⅛x36	500	14.50
24	13⅛x46	1000	16.25
30	13⅛x57	2000	18.50
40	13⅛x72½	3000	25.00
60	18 x59¾	4000	55.00
80	24 x45	4500	75.00

For two gauge glass tappings, add.....$4.0

Radiation capacities are based on forced circulation and smal pipes. On old systems use next larger size tank.

Heights, Sizes and Ratings of Thin Tube Cast Iron Radiator



Standard cast iron radiation measures 1¾" in length per sec tion. Add ½" to the length for each bushing.

Number Tubes	Width Inches	Sq. Ft. of Radiation per Section of Various Height Radiato 19"	22"	25"	32"
3	3½	...	...	1.6	...
4	4¼	1.6	1.8	2.0	...
5	6	...	2.1	2.4	...
6	7¼	2.3	...	3.0	3.7

Approximate Prices of Thin Tube Radiators

Sold only in even number of sections.

eight, Inches	19"	22"	25"	32"
umber of Tubes	4-6	4-5	3-4-5-6	6
rice, 100 sq. ft.	$138.00	$135.00	$129.00	$138.00

Radiant Baseboard Panels

Radiant baseboard panels are produced and marketed by a umber of concerns. Some are made of cast iron, others having finned pipe covered with a steel facing or cover.

They are made in various heights from 7" to 9" and usually xtend out from the wall 1¾" to 2½", depending upon the manu-acturer.

Rated Heat Emission of Radiant Baseboard Panels

Rating in sq. ft. is based on standard emission of 240 BTU er hour per sq. ft. at average temperature of 215°.

9⅞ Inch Radiant Panel Baseboard

ating q. Ft.	Water Flow Lbs. per Hr.	Heat Output BTU per Hour per Lin. Ft. of Panel 220°	210°	200°	190°	180°	170°	160°	150°
1.95	500	460	420	380	350	310	270	240	200
1.95	2,500	490	450	410	370	330	290	250	210

9⅞ Inch Radiant Convector Panel

Rating based on standards given for baseboard panels.

ating q. Ft.	Water Flow Lbs. per Hr.	Heat Output BTU per Hour per Lin. Ft. of Panel 220°	210°	200°	190°	180°	170°	160°	150°
3.25	500	780	720	660	600	530	470	420	350
3.25	2,500	830	760	700	640	570	510	440	380

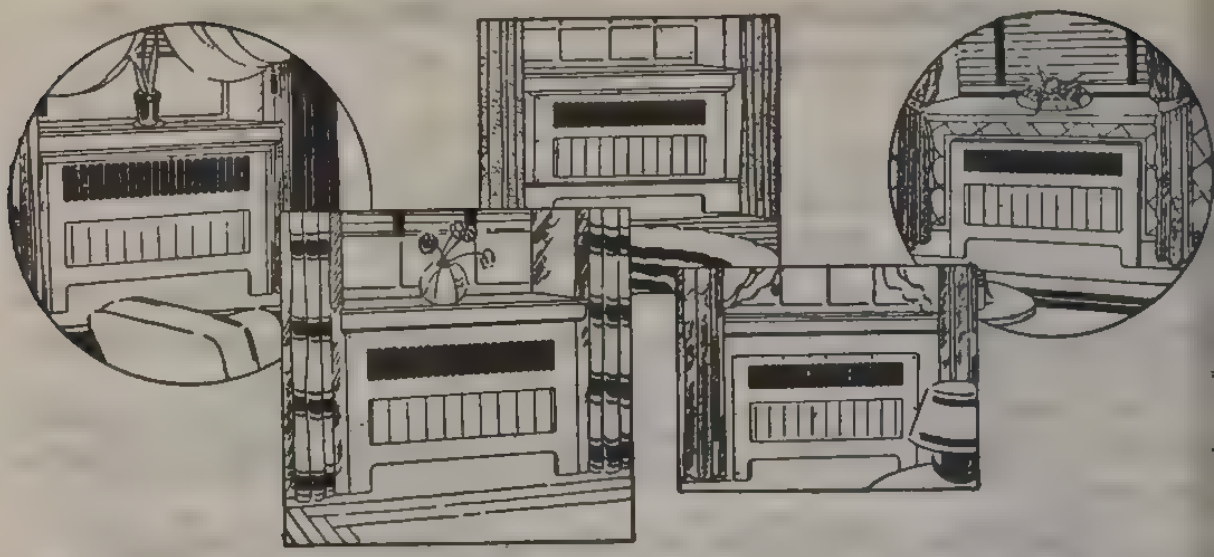
Prices of Baseboard Radiation and Accessories

Description	Weight Pounds	Approx. Price
Radiant Baseboard Panels 9⅞", Price per lin. ft...	12.25	$ 2.50
Radiant Convector Panels 9⅞", Price per lin. ft...	14.00	3.50
Plain Ends, 9⅞", Price each.....	2.50	1.30
Corner Plate, 9⅞", Price each.....	.50	1.20
Angle Radiator Valve, ¾", Price each	1.00	3.30
Malleable Union Elbow, ¾", Price each.....	.75	1.30
Assembly Tool, Price each	11.00	12.00

Convector-Radiators

Radiant convectors combine convection heating with quick-cting and comfortable radiant heating. They are formed of cast ron with finned sections or of copper, with or without finned ections, depending upon the manufacturer.

There are so many types of convectors it is impossible to de-cribe all of them in detail.



Types of Standard Radiant Convectors and Cabinets

Convectors described below are 6¼" deep overall and may be installed as free-standing or semi-recessed units. Maximum depth of recess should not exceed 4¾".

Sizes, Capacity and Approximate Prices of Convectors

Height Inches	Length Inches	CAPACITIES Steam Sq. Ft. E.D.R.	Forced Hot Water, 1,000 BTU per Hr. 180°	200°	220°	Price Each
20	16	13.0	1.74	2.17	2.60	$13.00
20	20	17.0	2.28	2.84	3.40	14.50
20	24	21.0	2.81	3.51	4.20	16.00
20	28	26.0	3.48	4.34	5.20	17.50
20	32	29.5	2.95	4.93	5.90	19.00
20	36	33.5	4.48	5.59	6.70	20.00
20	40	38.5	5.15	6.43	7.70	22.00
20	44	43.5	5.82	7.26	8.70	23.00
20	48	46.5	6.22	7.76	9.30	24.00
20	56	55.5	7.43	9.26	11.10	27.00
20	64	63.0	8.44	10.50	12.60	30.00
24	20	18.5	2.48	3.09	3.70	15.00
24	24	23.0	3.08	3.84	4.60	16.50
24	28	28.0	3.75	4.67	5.60	18.00
24	32	32.5	4.35	5.42	6.50	19.50
24	36	36.5	4.88	6.09	7.30	21.00
24	40	42.0	5.62	7.01	8.40	23.00
24	44	47.5	6.36	7.93	9.50	24.50
24	48	51.0	6.83	8.51	10.20	25.50
24	56	60.5	8.18	10.10	12.10	29.00
24	64	69.0	9.24	11.52	13.80	31.00

For dampers, add $1.50. For air chambers and accessories, less air valve, Add $2.00.

For southern, southwestern, western and northwestern states, dd about 5 percent to the above prices.

Sizes and Approximate Prices of Cast-Iron Sectional Boilers

Steam			Hot Water			
Installed Radiation Sq. Ft.*	Price Each With Jacket	Price Each Without Jacket	Installed Radiation Sq. Ft.*	BTU Rating	Price Each With Jacket	Price Each Without Jacket
			For Oil Firing			
845	$ 515.00	$ 461.00	1500	225,000	$ 509.00	$ 455.00
090	593.00	538.00	1910	287,000	592.00	537.00
340	646.00	590.00	2320	348,000	644.00	588.00
600	729.00	672.00	2735	410,000	723.00	665.00
860	787.00	728.00	3145	472,000	782.00	722.00
120	871.00	809.00	3560	534,000	865.00	802.00
380	922.00	858.00	3960	594,000	908.00	844.00
650	1,006.00	937.00	4375	656,000	997.00	927.00
920	1,068.00	994.00	4785	718,000	1,059.00	985.00
200	1,155.00	1,077.00	5205	781,000	1,146.00	1,067.00
480	1,227.00	1,143.00	5620	843,000	1,217.00	1,133.00

Above prices are net to the heating contractor, f.o.b. factory. Prices nclude boiler trimmings.

*Capacities are based on net installed radiation and on the presence f a quantity of net installed radiation sufficient for the requirements f the building. Nothing need be added for normal piping.

All ratings are based on radiation at 240 BTU per sq. ft. for steam and 50 BTU per sq. ft. for water.

Sizes and Approximate Prices of Oil Burning Boiler Units

Price includes boiler complete with oil burner, trombone tank ype water heater or tankless type water heater, steel jacket with aked enamel finish, aircell type insulation furnished with jacket, lain room thermostat, limit control and combustion control.

In addition, steam boiler prices include: low water cut-off, pop afety valve, try cocks, water gauge, pressure and vacuum gauge nd flue brush.

Water boiler prices include: combination altitude gauge and hermometer and flue brush.

Steam Boiler			Water Boiler			
Installed Radiation Sq. Ft.*	Jacketed Prices With Trombone Heater	Tankless Heater	Installed Radiation Sq. Ft.*	Net BTU Rating	Jacketed Prices With Trombone Heater	Tankless Heater
460	$521.00	$551.00	840	126,000	$499.00	$517.00
570	584.00	614.00	1030	155,000	562.00	579.00
680	636.00	666.00	1220	183,000	614.00	631.00
790	686.00	716.00	1405	211,000	664.00	681.00
900	738.00	768.00	1590	239,000	720.00	738.00

If boilers are furnished without tankless heater, deduct $30.00; less trombone tank type heater, deduct $12.00.

Water Heater Capacities

Tankless type ..... 4 gals. per minute
Trombone tank type .....66 gals. in 3 hours.

Above capacities are based on 40° to 140° rise with boiler water at 180°.

Above prices are f.o.b. factory. Prices include boiler trimmings as listed above.

Approximate Prices of Gas Fired Boilers for Hot Water Heating Systems

Furnished with finned cast iron sections to provide staggered heat travel, draft diverter, heavily insulated steel jacket with baked enamel finish.

Boiler price includes gas valve and hydraulic limit control, relay gas valve and recycling manual control switch, transformer, electric safety pilot, gas pressure regulator, manual gas shut-off valve, combination thermometer and altitude gauge, pilot pressure regulator, drain cock, pilot cock, draft diverter, gas manifold, tubing and fittings. Room thermostat not included. Prices are f.o.b. factory.

Net I-B-R Rating		A.G.A.	Price
Radiation Sq. Ft.	Output B.T.U./Hr.	Gross Output B.T.U./Hr.	Boiler Complete
515	77,500	103,000	$ 302.00
860	129,000	172,000	395.00
1205	181,000	241,000	505.00
1550	233,000	310,000	615.00
1720	258,000	344,000	663.00
1960	294,000	392,000	770.00
2240	336,000	448,000	849.00
2520	378,000	504,000	897.00
2800	420,000	560,000	928.00
3080	462,000	616,000	1,020.00
3350	502,500	672,000	1,095.00
3920	588,000	784,000	1,238.00
4480	672,000	896,000	1,411.00
5040	756,000	1,008,000	1,566.00
5600	840,000	1,120,000	1,719.00
6160	924,000	1,232,000	1,859.00
6666	1,000,000	1,344,000	1,989.00
7222	1,083,350	1,456,000	2,129.00
7777	1,166,650	1,568,000	2,282.00
8333	1,250,000	1,680,000	2,444.00
8888	1,333,300	1,792,000	2,604.00
9444	1,416,650	1,904,000	2,766.00

Approximate Prices of Gas Fired Boilers for Steam and Vapor Heating Systems

Furnished with finned cast iron sections to provide staggered heat travel, draft diverter, heavily insulated steel jacket with baked enamel finish.

Boiler price includes gas valve, relay gas valve and recycling manual control switch, transformer, electric safety pilot, gas pressure regulator, pilot pressure regulator, manual gas shut-off valve, electric hot water cut-off, steam pressure regulator, retard steam gauge, pop safety valve, water gauge, try cocks, drain cock, pilot and burner cocks, draft diverter, gas manifold, tubing and fittings. Room thermostat not included. Prices are f.o.b. factory.

Net I-B-R Rating		A.G.A.	Price
Radiation Sq. Ft.	Output BTU/Hr.	Gross Output BTU/Hr.	Boiler Complete
280	66,750	103,000	$ 343.00
475	113,500	172,000	434.00
670	161,000	241,000	544.00
875	210,000	310,000	650.00
980	235,000	344,000	698.00
1121	269,100	392,000	803.00
1293	310,250	448,000	882.00
1466	351,700	504,000	930.00
1641	393,800	560,000	961.00
1996	478,950	672,000	1,136.00
2353	565,250	784,000	1,275.00
2717	652,100	896,000	1,448.00
3081	739,550	1,008,000	1,603.00
3449	827,800	1,120,000	1,747.00
3814	915,300	1,232,000	1,887.00
4167	1,000,000	1,344,000	2,017.00
4514	1,083,350	1,456,000	2,157.00
4861	1,166,650	1,568,000	2,306.00
5208	1,250,000	1,680,000	2,468.00
5555	1,333,300	1,792,000	2,628.00
5903	1,416,650	1,904,000	2,790.00

Net boiler load is the amount of actual installed radiation which may be attached to the boiler, based on a heat emission rate from the radiators of 240 BTU per sq. ft. for steam and 150 BTU for gravity hot water. For forced circulation for hot water systems, select the boiler from the net BTU column.

Standard Black and Galvanized Steel Pipe

Inside Diameter Inches	BLACK PIPE Price Per Lin. Ft.	GALV. PIPE Price Per Lin. Ft.	Threads Extra Each End
¼	$0.14	$0.18	$0.30
⅜	.16	.19	.30
½	.16	.19	.30
¾	.20	.25	.30
1	.29	.35	.30
1¼	.39	.46	.35
1½	.45	.55	.42
2	.63	.75	.55
2½	.96	1.20	.90
3	1.26	1.58	1.15

Above prices are for pipe cut to order. Add for threads as given.

Prices of Steam Radiator Valves

	Size in Inches ½	¾	1	1¼	1½	2
Angle steam radiator valve	$4.42	$4.78	$ 5.41	$ 6.62	$11.87	$18.38
Gate steam radiator valve	7.82	9.50	11.39	14.60	19.64	...

Prices of Water Radiator Valves

	½	¾	1	1¼	1½
Hot water radiator valve	$2.46	$2.89	$7.65	$...	$...
Hot water radiator union ell	1.73	2.15	3.26	4.46	6.30

Prices on Floor and Ceiling Plates

Floor and ceiling plates made of cold rolled steel, halves securely riveted by a concealed hinge. Can be opened or closed on pipe without effort.

For Pipe size in inches	½	¾	1	1¼	1½	2	2½	3
Chrome plated, each	$0.18	$0.18	$0.19	$0.22	$0.23	$0.27	$0.38	$0.47

125 Lb. W.P. Brass Valves

Size in inches	½	¾	1	1¼	1½	2
Globe	$6.40	$ 8.80	$11.40	$15.40	$20.00	$30.20
Gate	7.80	9.60	11.80	15.60	20.00	28.20
Swing	8.60	10.00	12.80	16.80	19.60	28.00

Copper Pipe

The cost of copper pipe on heating work depends to a large extent upon the experience of the steam fitter installing same. The technique of installing copper pipe is entirely different from that of steel pipe. Inexperienced steam fitters figure more for labor than on a steel pipe job, while others figure the same for labor, whether steel or copper. Steam fitters who are thoroughly experienced in installing copper pipe and fittings and who are equipped to handle same efficiently state they can install copper pipe for 15 to 20 percent less than steel pipe.

The price of the pipe itself is subject to wide fluctuations, due to the price of copper so that prices on copper pipe and fittings should ALWAYS be obtained for each job.

Copper pipe is furnished in 3 weights, as follows:

Heavy Copper Pipe (Government Type "K") for underground service, such as water, gas, steam, oil lines, industrial uses, also interior plumbing.

Standard Copper Pipe (Government Type "L") for interior plumbing and heating.

Light Copper Pipe (Government Type "M") for low pressure interior plumbing.

Sizes and Weights of Copper Pipe

	TYPE "K" HEAVY		TYPE "L" STANDARD		TYPE "M" LIGHT	
Nominal Size Inches	Wall Thickness Inches	Weight per Lin. Ft. Lbs.	Wall Thickness Inches	Weight per Lin. Ft. Lbs.	Wall Thickness Inches	Weight per Lin. Ft. Lbs.
⅜	.049	.269	.035	.198	.025	.145
½	.049	.344	.040	.285	.028	.204
⅝	.049	.418	.042	.362	....	....
¾	.065	.641	.045	.455	.032	.328
1	.065	.839	.050	.655	.035	.465
1¼	.065	1.04	.055	.884	.042	.681
1½	.072	1.36	.060	1.14	.049	.940
2	.083	2.06	.070	1.75	.058	1.46
2½	.095	2.93	.080	2.48	.065	2.03
3	.109	4.00	.090	3.33	.072	2.68
3½	.120	5.12	.100	4.29	.083	3.58
4	.134	6.51	.110	5.38	.095	4.66
5	.160	9.67	.125	7.61	.109	6.66
6	.192	13.87	.140	10.20	.122	8.91
8	.271	25.90	.200	19.30	.170	16.46
10	.338	40.30	.250	30.10	.212	25.60
12	.405	57.80	.280	40.40	.254	36.70

On account of the smooth inside surface of copper pipe, usually one size smaller pipe can be used than where steel pipe is used. Outside diameter of pipe is $\frac{1}{8}$" more than nominal size of tubing.

Approximate Prices on Copper Tubing

Prices on copper tube and fittings are subject to wide fluctuations due to the fluctuations in the price of copper. Always check prices before submitting bids.

Copper Tubing

	Nominal Size							
Price per lin. ft.	¼"	⅜"	½"	⅝"	¾"	1"	1¼"	1½"
Type "K"	$0.193	$0.353	$0.448	$0.567	$0.806	$1.06	$1.32	$1.74
Type "L"	.18	.253	.365	.492	.592	.856	1.15	1.47

Price per lin. ft.	2"	2½"	3"	3½"	4"	5"	6"
Type "K"	$2.66	$3.70	$5.06	$6.53	$8.36	$13.23	$19.50
Type "L"	2.33	3.28	4.31	5.62	7.06	10.52	14.63

When purchased in quantities of more than 2,000 ft. or lbs., whichever is greater, deduct 12 percent from above prices.

Prices of Brass Solder-Joint Valves

These valves are made for use with copper tubing and can be used for steam or water service.

	Size in Inches					
Description of Fitting	½"	¾"	1"	1¼"	1½"	2"
Gate valve	$5.60	$6.80	$8.80	$11.00	$13.40	$19.80

Approximate Quantity of Solder and Flux Required to Make 100 Joints

Size, Ins.	⅜"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	3½"	4"	5"	6"	8"	10"
Solder, Lbs.	½	¾	1	1½	1¾	2	2½	3½	4½	5	6½	9	17	35	45
Flux, Oz.	1	1½	2	3	3½	4	4	7	9	10	13	18	34	70	90

Estimating the Cost of Pipe and Fittings.—To estimate the cost of pipe and fittings required for any heating plant, obtain the total number of square feet of radiation in the job (based on cast iron radiation) and figure at 40 to 50 cts. per square foot. This is based on prices of pipe as given on the previous pages.

For one story residences having short pipe runs, figure the cost of the pipe and fittings at 40 cents per square foot of radiation (based on standard cast iron radiation).

If wrought iron pipe is used instead of steel, figure the cost of pipe and fittings at 70 to 80 cents per square foot of radiation (based on standard cast iron radiation).

An example of the method used in estimating the cost of pipe and fittings is as follows: For a job containing 1,400 square feet of standard radiation, take 40 per cent of 1,400 gives 560, or the pipe and fittings would cost $560.00.

The above allowances for pipe and fittings do not include radiator valves, floor and ceiling plates, boiler fittings, expansion tanks, etc., but only the pipe and fittings required for roughing-in the job.

LABOR INSTALLING HEATING PLANTS

The labor cost of installing steam, hot water, vapor and vacuum heating systems is usually figured on the basis of the number of radiators or convectors (commonly termed units) in the job, and estimated at a certain price per unit. This allowance includes all necessary labor to rough-in the job, set and connect boiler, set and connect radiators, convectors or baseboard radiation, and complete the job ready to operate.

This allowance varies with the type of heating system, whether a one or two-pipe system and the class of building in which it is installed.

Labor Installing One-Pipe Heating Systems in One Story Houses.—To install one-pipe heating systems in one story houses, it will require about 7 hours steam fitter per unit (per radiator), and the labor cost per unit should average as follows:

	Hours	Rate	Total	Rate	Total
Steam fitter	7	$.....	$.....	$8.00	$ 56.00

Labor Installing One-Pipe Heating Systems in Two Story Residences.—When installing one-pipe heating systems in two story residences, it will require about 10 hours steam fitter time per unit (per radiator), and the labor cost per unit should average as follows:

	Hours	Rate	Total	Rate	Total
Steam fitter	10	$.....	$.....	$8.00	$ 80.00

Labor Installing One-Pipe Heating Systems in 2 or 3-Story "Flat" or Apartment Buildings.—When installing one-pipe heating systems in 2 or 3-story "flat" or apartment buildings, figure about 8 hours steam fitter time per unit (per radiator), and the labor cost per unit should average as follows:

	Hours	Rate	Total	Rate	Total
Steam fitter	8	$.....	$.....	$8.00	$ 64.00

Labor Installing One-Pipe Steam Heating Systems in Stores, Theaters, Public Garages, One Story Factory and Warehouse Buildings.—When installing one-pipe steam heating systems in any of the buildings listed above, figure about 16 hours steam fitter time per unit (per radiator), and the labor cost per unit should average as follows:

	Hours	Rate	Total	Rate	Total
Steam fitter	16	$.....	$.....	$8.00	$128.00

Labor Installing Two-Pipe Hot Water Heating Systems in One Story Houses.—When installing two-pipe heating systems such as mentioned above in one story houses, figure about 14 hours steam fitter time per unit (per radiator), and the labor cost per unit should average as follows:

	Hours	Rate	Total	Rate	Total
Steam fitter	14	$.....	$.....	$8.00	$112.00

Labor Installing Two-Pipe Hot Water Heating Systems in 2 or 3-Story Apartment Buildings.—When installing two-pipe heating systems in 2 or 3-story apartment buildings, figure about 14 hours steam fitter time per unit (per radiator), and the labor cost per unit should average as follows:

	Hours	Rate	Total	Rate	Total
Steam fitter	14	$.....	$.....	$8.00	$112.00

Labor Installing Two-Pipe Hot Water Heating Systems in Residences and Other Types of Buildings.—When installing two-pipe heating systems in residences or other types of buildings not specifically mentioned, figure 16 hours steam fitter time per unit (per radiator), and the labor cost per unit should average as follow:

	Hours	Rate	Total	Rate	Total
Steam fitter	16	$.....	$.....	$8.00	$128.00

Labor Connecting One or More Radiators in Tandem.—When connecting one or more cast-iron radiators in tandem, figure 14 hours steam fitter time for the first unit and 7 hours for each additional unit.

Labor Hanging Cast-Iron Radiators On Walls and Ceilings.—When hanging cast-iron radiators on walls, a steam fitter should hang 15 to 17 square feet an hour or 120 to 136 square feet per 8 hour day, at the following labor cost per 100 square feet:

	Hours	Rate	Total	Rate	Total
Steam fitter	6.3	$.....	$.....	$8.00	$ 50.40
Cost per sq. ft.			.....		.504

When hanging cast-iron radiation on ceilings, a steam fitter should hang 11 to 13 square feet of radiation an hour, or 88 to 104 square feet per 8 hour day, at the following labor cost per 100 square feet:

	Hours	Rate	Total	Rate	Total
Steam fitter	8.5	$.....	$.....	$8.00	$ 68.00
Cost per sq. ft.			.....		.680

Washing Out Boiler.—For washing out boilers, take rating of boiler in square feet and figure at 6 cents per square foot.

Heating Contractor's Overhead Expense and Profit.—This will vary with the competition and market conditions, but for small work—residences, stores, etc.—10 percent for overhead plus 10 percent for profit is about average. For large work—office and hotel buildings, industrial plants, etc.—5 percent for each is usual and may drop to 5 percent for both overhead and profit, on very large work.

Running Pipe In Tile Conduit.—When running heating pipes underground in 4-inch tile pipe, figure the work at $1.80 per lineal foot, including labor excavating a trench 2 feet deep, cost of tile and labor placing.

If the heating pipes are placed in 6-inch tile, figure the work at $2.20 per lineal foot, including excavating trench 2 feet deep, cost of tile and labor placing.

If heating pipes are placed in split tile, add 20 percent to the above prices.

Labor Connecting Temporary Radiators.—When connecting radiators for temporary heat during the construction of a building, figure the following for each temporary radiator in the job:

One Pipe Systems	Hours	Rate	Total	Rate	Total
Steam fitter	5	$.....	$.....	$8.00	$40.00
Two Pipe Systems	**Hours**	**Rate**	**Total**	**Rate**	**Total**
Steam fitter	6.5	$.....	$.....	$8.00	$52.00
Hot Water Heating Systems	**Hours**	**Rate**	**Total**	**Rate**	**Total**
Steam fitter	8	$.....	$.....	$8.00	$64.00

Trucking on Boilers and Radiation

When estimating the trucking on boilers and radiation from cars or warehouses to jobs, the following data will prove useful:

Figure $1.00 per cwt. (100 lbs.) for hauling cast-iron sectional boilers.

Figure 4 cents per pound for hauling and unloading steel firebox boilers, pumps, tanks, hot water heaters, etc.

Figure 5 cents per square foot of radiation for hauling cast-iron radiation.

PIPE AND BOILER COVERING

Cost of Covering Boilers.—When covering boilers and breechings with 1½ inches of standard grade asbestos boiler covering, figure $2.00 to $2.50 per square foot of surface covered, including labor and material. If wire lath is used to reinforce the asbestos, add 50 cents per square foot.

Approximate Quantities of Asbestos Required to Cover Sectional Steam and Hot Water Boilers, 1¼ Inches Thick

Steam Rating Square Feet	Water Rating Square Feet	No. Pounds Asbestos Required
325	550	150
375	625	175
425	700	175
500	825	200
575	950	225
650	1075	225
750	1225	250
850	1400	275
950	1575	300
1100	1825	300
1225	2025	300
1350	2225	325
1500	2450	475
1800	2950	550
2100	3450	625
2400	3950	700
2700	4450	775
3000	4800	650
3500	5600	725
4000	6400	800
4500	7200	875
5000	8000	950
5500	8800	1025
6300	10000	950
7200	11500	1050
8100	13000	1150
9000	14500	1250
9900	16000	1350
10800	17500	1450
11250	18000	1340
12500	20000	1460
13750	22000	1580
15000	24000	1700

It requires about 6 pounds of asbestos boiler covering to cover one square foot of surface 1¼ inches thick.

Asbestos cement, price per 100 pounds.....$3.00

Cost of Covering Pipes for One-Pipe Steam Heating Systems.—The cost of covering all mains, branches and returns for one-pipe steam heating plants containing 5,000 square feet of radiation and under, should be figured at 50 cents per square foot of radiation.

Cost of Covering Pipes for Hot Water and Two-Pipe Steam, Vapor or Air Line Heating Systems.—The cost of covering all mains, branches and returns for two-pipe heating systems as described above, with 4-ply air cell, asbestos molded or wool felt covering, should be figured at 45 cents per square foot of radiation.

Cost of Covering Steam or Hot Water Risers.—When covering steam risers or sets of risers for hot water heating systems, with 4-ply air cell, asbestos molded or wool felt covering, figure the total number of feet of radiation attached to each riser at 25 cents per square foot of radiation.

Cost of 85 Percent Magnesia Covering.—When 85 percent magnesia pipe covering is used, add 50 percent to the above prices.

Asbestos Cement for Boiler Covering

Asbestos should be applied to a warm surface. About 24 hours before using, mix with water to the consistency of thin mortar, enough asbestos for the first coat, which should be one-half of the entire thickness of the covering. Cover the boiler, throwing on by handfuls with just enough force to make it stick without packing too solidly. The more loosely it is applied the more effective. When the first coat is thoroughly dry, apply the second coat in the same manner, having a thicker consistency. The third coat should be applied with a trowel and brought to a smooth finish. It is important for good results to allow each coat to thoroughly dry before applying the next. A canvas or heavy muslin jacket can now be pasted over the asbestos and made moisture-proof by painting with asphaltum. This will insure a permanent covering.

Pipe Covering

Pipe covering is furnished in several kinds of materials, corrugated air cell covering being the most common and cheapest for covering steam and hot water pipes; 85 percent magnesia pipe covering for high pressure steam work, and wool felt pipe covering for protecting pipes against freezing and pipe covering in general.

Pipe covering is usually furnished in 3 foot lengths, ¾ to 1-inch thick and is covered with a canvas jacket.

Labor Applying Asbestos Boiler Covering.—When applying

asbestos cement to sectional boilers, an experienced pipe coverer should cover 6 to 8 square feet of surface an hour, or 48 to 64 square feet per 8 hour day.

When the dimensions of the boiler are not known, take the number of pounds of asbestos given in the above tables, for a boiler of any size, and divide by 6, and the result will be the approximate number of square feet of surface to cover. It requires about 6 pounds of asbestos to cover one square foot of surface 1¼ inches thick.

Labor Covering Pipes Up to 3 Inches in Diameter.—When placing covering on pipes up to 3 inches in diameter, a pipe coverer should apply 10 to 15 lineal feet of covering an hour, or 80 to 120 lineal feet per 8 hour day, and the labor cost per 100 lineal feet should average as follows:

	Hours	Rate	Total	Rate	Total
Pipe coverer	8	$.....	$.....	$8.00	$64.00
Cost per lin. ft.			.....		.640

Labor Covering Pipes 4 to 6 Inches in Diameter.—When placing covering on pipes 4 to 6 inches in diameter, a pipe coverer should apply 9 to 11 lineal feet of covering an hour or 72 to 88 lineal feet per 8 hour day, and the labor cost per 100 lineal feet should average as follows:

	Hours	Rate	Total	Rate	Total
Pipe coverer	10	$.....	$.....	$8.00	$80.00
Cost per lin. ft.			.....		.80

When estimating quantities of pipe covering, add one lineal foot of covering for each fitting up to 2-in. pipe and two lineal feet of covering for each fitting on pipe over 2 inches.

Temperature Regulators for Heating Plants

Temperature regulators and thermostats are furnished in a variety of different models for controlling the temperature.

There are so many different methods of controlling the inside temperature with straight thermostats, day and night thermostats, inside-outside controls, etc., that it is practically impossible to give even a fraction of them in a book of this kind.

Temperature Regulators With Clock.—The thermostat with a clock attachment automatically lowers the temperature at night and raises it in the morning. Electric clocks are now usually furnished with all thermostats of this type.

Models of this kind are furnished with thermometer, clock, electric motor, chain, pulleys, transformer and fittings, at the following approximate prices:

Thermostat complete with electric clock.....$50.00

Temperature Regulators Without Clock.—Many thermostats or regulators are used without the clock attachment and are either manually operated or the same temperature maintained day and night.

There are a number of different types of regulators on the market and they vary in price from $18.00 to $50.00, depending upon the method of wiring and number of controls necessary.

Labor Installing Thermostats.—An experienced mechanic should install any of the above thermostat outfits in 1 to 2 hours. If they are installed by the manufacturers in cities where they maintain offices, a charge of $50.00 to $65.00 is usually made.

Making Up a Complete Estimate on a Steam Heating Plant.—When making up an estimate on a steam heating system, the following items should always be included in order that the estimate may be complete in every detail.

1. Boiler
2. Oil burner or stoker.
3. Radiators or convectors.
4. Radiator valves.
5. Automatic air valves.
6. Pipe and fittings.
7. Smoke pipe.
8. Special foundation, if required.
9. Asbestos boiler covering.
10. Pipe covering.
12. Painting radiators.
13. Thermostat regulator.
14. Freight and trucking.
11. Floor and ceiling plates.
15. Water connection.
16. Labor installing system.
17. Bond and insurance.
18. Overhead and misc. expense.
19. Estimated profit.

Making Up a Complete Estimate on a Hot Water Heating Plant.—When making up an estimate on a hot water heating plant, the following items should always be included in order that the estimate may be complete in every detail.

1. Special boiler foundation, if required.
2. Boiler.
3. Oil burner or stoker.
4. Pipe and fittings.
5. Radiators or convectors.
6. Radiator valves-union ells.
7. Circulating pumps.
8. Compression air valves.
9. Expansion tank and gauge.
10. Altitude gauge.
11. Thermometer.
12. Smoke pipe.
13. Painting radiators.
14. Boiler covering.
15. Pipe covering.
16. Floor and ceiling plates.
17. Thermostat regulator.
18. Labor installing system.
19. Freight and trucking.
20. Water connection.
21. Bond and insurance.
22. Overhead and miscellaneous expense.
23. Estimated profit.

Unit Heaters.—Unit heaters are often used to heat commercial and industrial areas, garages, and to supplement other heating units at entrances. They may be direct-fired by gas, oil or electricity, or have hot water or steam piped to them. Direct-fired are cheaper when only a few units are required and no central plant is available. Hot water and steam are the most common units in use where a central plant is available or its cost justified by the number of units it serves.

Units may have propeller or centrifugal fans blowing either horizontally, up or down. Air may be drawn through or blown through, the latter being used for direct-fired units.

The following costs do not include valves, fittings or piping which will vary widely with job conditions and are based on units served with 2 lbs. steam, 60° entering air, single phase 115 volts.

			Cost		
Type	H. P.	BTU	1 Speed	2 Speed	Installation Time
Horizontal Delivery	1/40	25,000	$ 84.00	$ 96.00	1 hour
	1/15	50,000	126.00	138.00	1½ hours
	1/10	100,000	150.00	152.00	2½ hours
	1/5	200,000	260.00	—	4 hours
Vertical Delivery	1/40	50,000	145.00	155.00	1½ hours
	1/12	100,000	200.00	220.00	2 hours
	1/3	200,000	300.00	315.00	5 hours
Cabinet	1/20	25,000	145.00	—	1½ hours
	1/12	60,000	190.00	—	2 hours
	1/8	120,000	325.00	—	3 hours

For 230 volts, add $10.00.
For ceiling suspension, add $10.00.

CHAPTER XXIX

PLUMBING AND SEWERAGE

To prepare an accurate detailed estimate on plumbing and sewerage requires a working knowledge of the trade because all work must be laid out on paper and the number of lineal feet of each kind of pipe estimated separately, such as tile or cast iron sewers, soil and vent pipe, water pipe, gas pipe, drains, valves, pipe fittings, etc. Inasmuch as very few, if any, general building contractors or estimators possess this knowledge, it makes it doubly difficult for them to prepare more than an approximate estimate on the various kinds of plumbing work.

In making up an approximate estimate on plumbing, the average contractor counts the number of fixtures in the job and multiplies at a certain price per fixture, and that is usually the extent of the estimate. Before going into the matter of detail estimating, average prices will be given on plumbing fixtures installed in the building.

Approximate Prices of Plumbing Fixtures Installed in the Building.—The method commonly used to obtain approximate costs on plumbing work is to count the number of fixtures in the job, such as kitchen sinks, lavatories, water closets, bathtubs, shower baths, laundry tubs, etc., and estimate them at a certain price per fixture, installed.

This method of estimating has become more complicated during recent years, due to the great changes that have been made in plumbing fixtures both as to style, materials and color. Building code requirements vary widely in different localities and this has a great influence on costs, as do the rates of wages paid in different parts of the country.

For this reason the installed prices of plumbing fixtures given in the following paragraphs can only be approximates and should be regarded as such; also all prices are based on using white fixtures, similar to those shown in the illustrations. Any changes or additions for colored fixtures, cabinet sinks, electric dishwashers, lavatories, etc., should be made in accordance with the detailed fixture prices.

The approximate prices given include complete roughing-in inside the building, together with all necessary tile drains and sewers inside the building and extending 20 ft. on the outside.

The difference in cost between individual house type structures and apartment buildings is due to the fact that in apartment building construction, one stack will often suffice for two or more sets of fixtures, while in individual houses, separate stacks are usually required for each group of fixtures. One set of laundry tubs in the basement is often sufficient for 3 apartments. This also applies to sewers, as in apartment building construction, one sewer will be sufficient for 2 or more apartments, which reduces the cost.

The approximate prices given are based on material prices as given in this chapter and plumbers' wages, plus welfare and pension, at $8.50 per hour.

In one or two story houses, using bathroom fixtures similar to those illustrated in Fig. 1, consisting of a porcelain enameled steel or cast iron tub, a porcelain enameled cast iron wall lavatory and a vitreous china washdown closet outfit; a porcelain enameled single compartment flat rim kitchen sink, a 2-compartment granitine laundry tub and a hot water heater with gas connection or connected to heating boiler, should average $445.00 to $505.00 per fixture or $2225.00 to $2525.00 for the job complete.

Using the same grade of fixtures in a 2 or 3-story apartment building, the cost should run from $365.00 to $445.00 per fixture, or $1825.00 to $2225.00 per apartment.

In one or two story houses, using bathroom fixtures similar to those illustrated in Fig. 2, consisting of a vitreous china lavatory with legs, a vitreous china closet outfit and a porcelain enameled cast iron recess bath; a porcelain enameled cast iron double compartment flat rim kitchen sink, a 2 or 3-compartment granitine laundry tub and a hot water heater with gas connection or connected to heating boiler, should average from $495.00 to $535.00 per fixture or from $2475.00 to $2685.00 for the complete job.

Using the same grade of fixtures on a 2 or 3-story apartment building, the cost should run from $415.00 to $475.00 per fixture or from $2075.00 to $2375.00 per apartment.

In one or two story houses, using bathroom fixtures similar to those illustrated in Fig. 3, consisting of a vitreous china lavatory with legs, a vitreous china siphon jet closet combination and a porcelain enameled cast iron bath with shower complete as illustrated; a double flat rim kitchen sink, a 2 or 3-compartment granitine laundry tub, a gas-fired storage water heater or

connected to heating boiler, should average from $505.00 to $550.00 per fixture or from $2525.00 to $2750.00 for the complete job.

Using the same grade of fixtures on a 2 or 3-story apartment building, the cost should run from $445.00 to $505.00 per fixture or from $2225.00 to $2525.00 per apartment.

In one or two story houses, using bath room fixtures similar to those illustrated in Fig. 4, consisting of a vitreous china lavatory with chromium legs, a one-piece vitreous china closet combination and a porcelain enameled cast iron recess bath with shower complete; a double compartment flat rim kitchen sink, a 2 or 3-compartment granitine laundry tub, a gas-fired storage water heater or connected with heating boiler, should average from $535.00 to $600.00 per fixture or from $2675.00 to $3000.00 for the job complete.

Using the same grade of fixtures on a 2 or 3-story apartment building, the cost should run from $475.00 to $535.00 per fixture or from $2375.00 to $2675.00 per apartment.

Estimating Quantities and Costs of Sewer Work.—Sewerage is estimated by the lineal foot, obtained by measuring the number of lineal feet of each size sewer pipe required, such as 4", 6", 8" and 12" pipe, and all fittings should also be listed in detail, giving the number of ells, Ys, Ts, etc.

Cast-iron sewer pipe is estimated in the same manner as tile sewer pipe.

Most plumbers estimate their sewer work at a certain price per lineal foot, including excavating, sewer pipe and labor. This is all right on ordinary jobs that do not require more than the usual amount of deep excavation, but if there is an exceptionally large amount of deep excavation (from 7 to 15 feet deep), then the excavating should be estimated separately.

Undoubtedly the best method is to estimate the number of cubic yards of excavating required for sewers, based on a trench 1'-6" wider than the pipe diameter by the required depth. Refer to Chapter on Excavating for labor costs excavating for trenches.

Where 4 to 6-inch sewer pipe is used, an experienced sewer layer should lay 12 to 15 lineal feet of pipe an hour or 100 to 125 lineal feet per 8 hour day, at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Sewer layer	7	$.....	$.....	$8.50	$59.50
Average per lin. ft.			.....		.60

Add for excavating and additional time for setting catch basins, gravel basins, triple basins, etc.

As an example of the method used, the cost of excavating a trench 3 feet deep, and placing 100 lineal feet of 6-inch tile sewer pipe, should be estimated as follows:

	Hours	Rate	Total	Rate	Total
Labor excavating	39.0	$.....	$.....	$5.00	$195.00
Labor backfilling	10.5	.....	.....	5.00	52.50
100 lin. ft. 6" pipe		.....	.....	.75	75.00
Pipe layer	7.0	.....	.....	8.50	59.50
Total cost 100 lin. ft. ...	56.5		$.....		$382.00
Average per lin. ft.....			.....		3.82

Estimating Quantities of Cast Iron Soil Pipe, Downspouts, Stacks and Vents.—When estimating soil pipe, stacks, vents, etc., note the number of stacks and length of each, listing the number of lineal feet of each size pipe; the number of pieces, size, and kind of fitting required, and price them at current market prices. The labor cost placing cast iron pipe is given on the following pages.

Estimating Quantity of Pipe and Fittings.—When estimating the quantity of black or galvanized pipe, list the number of lineal feet of each size pipe required, such as ½", ¾", 1", 1¼", 1½", 2", 2½", 3", etc., and estimate at the current market price.

After the cost of the pipe has been computed, take 60 to 75 percent of the cost of the pipe to cover the cost of all fittings required.

Brass or copper pipe and fittings should be estimated in the same manner as galvanized pipe.

Estimating the Quantity and Prices of Valves.—All valves of the different sizes should be listed on the estimate separately, stating the number of each size required, and pricing them at the current market price.

Estimating the Quantity of Fixtures.—Each type of fixture such as sinks, lavatories, laundry trays, water closets, bathtubs, drinking fountains, shower baths, hot water tanks and heaters, house pumps, bilge pumps, etc., should be listed separately and priced at the current market prices.

Labor Roughing in for Plumbing.—The usual practice among plumbers is to allow a certain percentage of the cost of the roughing materials to cover the labor cost of installing them. This will vary with the type of building and grade of work.

The total cost of the roughing in materials, such as cast-iron soil pipe, downspouts, stacks, vents, and fittings; also all black and galvanized pipe and fittings, all valves, increasers, tees, Ys, ½ bends, nipples; in fact, all pipe required to rough in the job is computed. Then the labor cost is estimated at a certain percentage of the cost of the pipe.

In medium price one and two story residences, the labor cost of roughing in the job will vary from 75 to 85 percent of the cost of the roughing in materials, with 80 percent a fair average.

In apartment buildings of non-fireproof construction, the labor cost of roughing in will average about 90 to 100 percent of the cost of the roughing in materials, while on high grade fireproof construction, the labor cost roughing in will run from 100 to 120 percent of the cost of the roughing in materials.

In public garages, the labor cost roughing in the job will average about 90 to 110 percent of the cost of the roughing in materials.

Sewer work is estimated separately from roughing in.

Labor Handling and Placing Plumbing Fixtures.—The labor cost handling and placing all kinds of fixtures, such as laundry tubs, kitchen sinks, lavatories, bathtubs, shower baths, water closets, drinking fountains, etc., is usually estimated at 25 to 30 percent of the cost of the fixtures.

Plumbing Contractor's Overhead Expense and Profit.—Plumbing contractors like to add 10 percent to the cost of their work for overhead expense, and an additional 10 percent for profit, but most frequently the jobs are let on the basis of a straight 10 percent or less, depending upon the competition and how badly the contractor needs the work.

Preparing Detailed Plumbing Estimates

When preparing detailed estimates on plumbing, it is necessary to list the quantity of each class of work separately, such as the number of lineal feet of 4", 6", and 8" sewers, and fittings; number of lineal feet of each size soil pipe, vents and fittings; number of lineal feet of water pipe and fittings of different materials and sizes; number of valves of the various kinds and sizes; number of each type of fixture required, such as hot water heaters, laundry trays, kitchen sinks, slop sinks, bathtubs, lavatories, water closets, shower baths, etc., together with a list of fittings and supplies required for each.

The following is a list of items the plumbing contractor should include in his estimate:

1. Sewerage, including double sewer system.
2. House tanks, foundations, etc.
3. Compression tanks, foundations, etc.
4. Sewer ejector and bilge pump and basins.
5. Iron, gravel, catch and other basins.
6. Water filters, foundations.
7. Water meter.

8. Soil and vent pipe and fittings.
9. Roof flashings.
10. Shower and urinal traps.
11. Closet bends.
12. Drum traps.
13. Lead, solder, sundries.
14. Inside downspouts.
15. Outside downspouts.
16. Downspout heads.
17. Iron sewer and fittings.
18. Floor drains.
19. Back water gates.
20. Service pipe to building.
21. Mason hydrant.
22. Stop cock and box.
23. Galvanized pipe and fittings.
24. Brass or copper pipe and fittings.
25. Valves, check valves.
26. Pet cocks, sill cocks, hose bibbs.
27. Hot water tank and heater.
28. Pipe covering, tank covering, heater covering, filter covering, painting.
29. Gas fitting, mains, ranges, heaters, etc.
30. Man-holes and covers.
31. Catch basins and covers.
32. Surface drain basins and covers.
33. Fire system, incl. pumps, hose, Siamese connection, meter, etc.
34. Roughing in material.
35. Fixtures, such as water closets, lavatories, bathtubs, shower baths, sinks, laundry tubs, drinking fountains, N. P. fittings.
36. Permits, insurance, trucking, freight, R. R. fare, telephone, watchman, etc.
37. Overhead expense.
38. Profit.

Lineal Foot Prices of Cast Iron Soil Pipe

Size	Single Hub		Double Hub	
	Service	Extra Heavy	Service	Extra Heavy
2"	$ .59	$ .68	$ .62	$ .72
3"	.78	1.03	.86	1.09
4"	.95	1.25	1.03	1.34
5"	1.48	1.72	1.56	1.81
6"	1.73	2.13	1.74	2.28
8"	3.05	3.85	3.36	4.24
10"	5.26	6.16	5.45	6.85
12"	7.05	8.56	7.80	9.59
15"	...	13.69	...	15.06

Prices of Cast Iron Soil Pipe Fittings

Description of Fitting	Size in Inches					
	2"	3"	4"	5"	6"	8"
Quarter bends, service	$0.66	$1.03	$1.59	$1.94	$ 2.89	$ 5.60
Extra heavy	.91	1.27	1.91	2.27	3.54	8.56
Eighth bends, service	.65	.92	1.29	1.68	2.21	7.05

Prices of Cast Iron Soil Pipe Fittings—Cont'd.

Description of Fitting	Size in Inches 2"	3"	4"	5"	6"	8"
Extra heavy	.73	1.09	1.54	2.00	2.54	8.56
Sanitary "T" and "Y" branches	1.04	1.78	2.42	4.19	4.47	10.90
Extra heavy	1.36	2.18	2.91	5.00	5.45	15.40
Plain traps, "S", "P" or ¾	1.44	2.31	3.06	8.03	9.21	17.99
Extra heavy	1.73	2.72	3.63	9.81	11.17	22.25
"T" cleanout	2.37	2.82	4.59	5.95	7.61	17.60
Extra heavy	2.70	3.55	5.32	6.93	9.08	21.40
Comb. "Y" and eighth bends	1.72	2.95	3.28	6.90	10.27	19.35
Extra heavy	2.13	3.45	4.00	8.36	12.53	23.11

Closet bends slip collar type—4"x4"x12"—$4.15; 4"x4"x18"—$5.30

Lineal Foot Prices of Buttweld Steel Pipe

Size	Standard Weight Black	Standard Weight Galvanized	Extra Heavy Black	Extra Heavy Galvanized
¼"	$0.12	$0.15	$0.15	$0.19
⅜"	.13	.16	.17	.21
½"	.14	.16	.17	.21
¾"	.18	.21	.22	.27
1"	.25	.30	.31	.38
1¼"	.33	.40	.43	.53
1½"	.40	.47	.52	.63
2"	.54	.65	.71	.87
2½"	.85	1.02	1.09	1.38
3"	1.11	1.33	1.45	1.85
3½"	1.49	1.77	1.90	2.46
4"	1.75	2.08	2.28	2.95

Labor to cut threads on steel pipe ¼"—$0.30; ½"—$0.30; ¾"—$0.30; 1"—$0.30; 1¼"—$0.35; 1½"—$0.42; 2"—$0.55; 2½"—$0.90; 3"—$1.15; 3½"—$1.40; 4"—$1.65.

Prices on Standard Malleable Iron Fittings

Type of Fitting		Size ½"	¾"	1"	1¼"	1½"	2"	2½"	3"	3½"	4"
90° Elbow, Straight	Black	$0.26	$0.33	$0.41	$0.60	$0.81	$1.23	$2.35	$ 3.56	$ 5.01	$ 6.45
	Galv.	.40	.50	.61	.93	1.27	1.89	3.68	5.57	7.84	10.13
90° Elbow, Reducing	Black	.29	.37	.47	.64	.94	1.35	2.50	4.06	5.32	6.95
	Galv.	.45	.55	.68	1.02	1.48	2.08	3.93	6.32	—	10.90

(Table continued on page 1588)

Prices on Standard Malleable Iron Fittings—Cont'd.

Type of Fitting		Size ½"	¾"	1"	1¼"	1½"	2"	2½"	3"	3½"	4"
Elbow - 45°											
	Black	$0.29	$0.37	$0.47	$0.64	$0.93	$1.29	$2.50	$ 3.89	$ 5.32	$ 7.28
	Galv.	.46	.55	.68	1.02	1.46	2.04	3.93	6.09	8.36	11.40
Tee - Straight											
	Black	.37	.48	.53	.90	1.12	1.66	3.00	4.53	7.03	8.74
	Galv.	.55	.70	.79	1.39	1.73	2.52	4.68	7.07	11.00	13.64
Tee - Reducing											
	Black	.41	.52	.61	.97	1.27	1.77	3.33	5.01	7.78	10.00
	Galv.	.61	.78	.92	1.54	2.00	2.77	5.20	7.84	12.15	15.66
Cross	Black	—	.77	1.08	1.41	1.77	2.83	4.53	7.30	—	12.63
	Galv.	—	1.19	1.68	2.23	2.81	4.43	7.07	11.40	—	19.70
Coupling	Black	.26	.31	.47	.61	.77	1.12	2.24	3.09	—	6.15
	Galv.	.32	.39	.59	.78	.93	1.34	2.68	3.62	—	7.71
Return Bend Med.											
	Black	.70	.84	1.01	1.54	2.17	3.60	—	—	—	—
	Galv.	.87	1.04	1.28	1.94	2.66	4.54	—	—	—	—

Lineal Foot Prices of Copper Water Tubing

	Normal Size ¼"	⅜"	½"	⅝"	¾"	1"	1¼"	1½"	2"	3"
Light	$0.15	$0.20	$0.27	$0.37	$0.44	$0.62	$0.89	$ 1.22	$ 1.97	$ 3.55
Medium	.18	.25	.37	.49	.59	.86	1.15	1.47	2.33	4.31
Heavy	.20	.35	.45	.57	.81	1.06	1.32	1.74	2.66	5.06

Prices of Wrought Copper Soldered Joint Fittings

Type		Nominal Size ¼"	⅜"	½"	⅝"	¾"	1"	1¼"	1½"	2"	3"
Coupling - Copper to Copper	Straight	$0.07	$0.08	$0.11	$0.22	$0.21	$0.42	$0.60	$0.76	$1.40	$3.35
	Reducing	.14	.15	.22	.47	.37	.68	1.26	1.39	1.98	7.80
Bushing - Flush		.24	.20	.19	.53	.27	.65	.98	1.27	3.30	—
Adapter - CP to MPT		.49	.49	.21	—	.32	.63	1.07	1.46	1.80	7.45
Union - Copper to Copper		1.61	1.61	.80	—	1.15	1.75	—	—	—	—
Cap		.08	.09	.09	.38	.22	.43	.78	1.16	1.80	6.20
Elbow 90°		.32	.32	.35	.54	.28	.53	.87	1.23	2.10	5.70
45°		.43	.35	.24	.63	.42	.69	1.06	1.40	2.05	7.30
Tee	Straight	.39	.44	.21	.99	.52	1.19	1.86	2.35	4.10	11.60
	Reducing	.39	.44	.53	1.12	.41	.83	1.13	1.59	2.95	8.00
Cross		3.00	4.00	5.00	—	—	—	—	—	—	—
Return Bend 2" c. to c.		—	—	.52	.76	1.35	—	—	—	—	—

Lineal Foot Prices For PVC Plastic Pipe

Type	Size ½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	6"
Schedule 40	$.156	$.208	$.309	$.118	$ .50	$ .67	$1.06	$1.40	$1.98	$3.50
Schedule 80	.20	.27	.39	.55	.667	.924	1.40	1.89	2.75	5.26
*For Threading Add	.66	.66	.90	.90	1.10	1.32	2.22	3.32	4.44	8.72
*Nipples - 2" Long	.59	.60	.73	.90	.96	1.32	—	2.95	5.22	—
4" Long	.64	.73	.94	1.18	1.17	1.54	—	3.28	6.36	—
6" Long	.73	.86	1.04	1.23	1.35	1.85	—	3.96	6.44	—
*90° Elbow	.92	1.18	1.45	1.70	1.97	2.69	5.72	9.62	14.37	32.76
*45° Elbow	.92	1.18	1.45	1.70	1.97	2.69	5.72	8.21	12.21	32.76
*Tee	1.11	1.31	1.54	1.94	2.32	3.11	7.88	15.12	22.69	47.12
*Cap	.84	1.03	1.16	1.37	1.56	2.01	5.20	5.29	8.05	—
*Straight Coupling	.84	1.03	1.16	1.37	1.56	2.19	3.68	4.48	9.07	14.13
*Unions	4.06	4.70	5.59	7.31	8.52	12.52	—	—	—	—

*Schedule 80 fittings only. Threading and grooving of schedule 40 pipe not recommended. Cutting is best accomplished by hand or power saw using blades with 6 to 9 teeth per inch with very little set.

Solvent cement costs $5.20 per quart for Schedule 80, $4.88 for 40.

Prices of Cast Iron Drum Traps

Drum trap with cover and gasket, 4"x8", 2 inlets.....$4.00
Drum trap with cover and gasket, 4"x8", 3 inlets..... 4.40

Floor Drains and Backwater Traps

Cast iron combination floor drain and brass disc-type backwater valve.

	Size in Inches 3"	4"
With polished brass top and strainer.....	$45.00	$47.70

Plain Cast Iron Floor Drains

	Size in Inches 6"x6"	9"x9"	13"x13"
C.I. with loose strainer, without bell trap...	$1.55	$ 3.30	$ 7.65
C.I. with loose strainer, with bell trap.....	1.85	3.70	7.70
C.I. with hinged strainer, with bell trap....	2.05	3.95	7.15
Same with brass top and strainers.....	8.24	15.05	26.88
Same with chromium top and strainers....	11.83	20.43	34.05

Sizes and Weights of Steel Storage Tanks

Black, heavy weight, welded, 100 lbs. working pressure.

Capacity Gallons	Dimensions Diam.		Length	Overall Length	Heavy Weight Welded
Tanks with One Convex and One Concave Head					
66	20″	x	4′	52″	225
82	20″	x	5′	64″	265
120	24″	x	5′	64″	340
140	24″	x	6′	76″	395
180	30″	x	5′	66″	480
220	30″	x	6′	78″	550
295	30″	x	8′	102″	680
Tanks with Two Convex Heads					
69	20″	x	4′	55″	220
85	20″	x	5′	67″	260
125	24″	x	5′	68″	320
147	24″	x	6′	80″	375
200	30″	x	5′	71″	450
235	30″	x	6′	83″	520
305	30″	x	8′	107″	650
350	36″	x	6′	85″	850
450	36″	x	8′	109″	1050
560	36″	x	10′	133″	1250
550	42″	x	7′	99″	1200
770	42″	x	10′	135″	1550
900	42″	x	12′	159″	1800
1050	42″	x	14′	183″	2100
1000	48″	x	10′	137″	2150
1200	48″	x	12′	161″	2500
1500	48″	x	15′	197″	3050
1800	48″	x	18′	233″	3550

Cast Iron Roof Drains

Type	Size 2″	3″	4″	5″	6″
Medium Size Sump & Flange with Increaser & Dome		$21.60	$23.40	$28.80	$37.80
Add for Deck Clamp		8.10	8.10	8.10	8.10
Small Roof Sump Dome Type	$ 9.90	9.90	9.90		
Sill or Cornice Drain	15.30	17.10	17.10		
Scupper Drain	26.10	26.10	26.10	52.25	52.25

Adjustable Roof Flashings

Adjustable roof flashings for flat or pitched roof

Size Inches	Price Turn Down Type	Price Caulking Type
1½	$2.53	$2.44
2	2.60	2.60
3	3.00	2.95
4	3.20	3.15
5	3.47	4.72
6	4.87	6.75

Prices on Pipe Covering

For prices on pipe covering and labor installing same, see data under "Heating and Air Conditioning" Chapter.

Septic Sewage Disposal Tanks

Septic tanks are used in rural or suburban districts where running water is available but no sewers, and are used for homes, hotels, summer resorts, etc.

The capacity of a septic tank should be at least equal to the maximum daily flow of sewage. This is normally estimated at 50 gallons per person per day. For part time service in factories, churches, schools, etc., 25 gallons per person per day is generally satisfactory for estimating tank capacities. In some localities, health authorities require at least a 500 gallon tank for residential installation.

They are commonly furnished in 10 to 14 gauge copper bearing steel, electrically welded and covered with a thick coating of asphalt to protect the tanks against corrosive action.

Size of Tank	Capacity Gallons	Size Tile Connection	Weight Pounds	Capacity Home Use No. Persons	Price Each
60"x34"x44"	300	4"-6"	270	5— 6	$124.80
72"x34"x57¼"	500	4"-6"	430	6— 7	182.40
86½"x34"x57¼"	600	4"-6"	490	7—10	214.40
54" dia.x60"	500	6"	395	6— 7	153.00
54" dia.x70"	600	6"	435	7—10	177.60

Prices of Brass Valves

Kind of Valve	Size in Inches ½"	¾"	1"	1¼"	1½"	2"	2½"	3"
Gate valve, 100 lbs. pressure	$5.60	$6.80	$8.80	$11.00	$13.40	$19.80	$....	$....
Gate valve, 125 lbs. pressure	7.40	9.00	11.20	14.80	19.00	26.80	49.40	69.00
Globe valve, 100 lbs. pressure	5.00	6.20	8.80	11.00	14.60	22.40	....	....
Globe valve, 125 lbs. pressure	5.20	7.60	9.80	13.20	17.20	26.00	44.20	68.00
Check valve, horizontal, 125 lbs...	5.20	7.60	9.80	13.20	17.20	26.00	44.20	68.00
Check valve, vertical	7.40	8.60	11.00	14.40	17.00	24.20	43.00	61.40

Angle valves, same price as Globe valves.

PRICES ON PLUMBING FIXTURES

Prices on Plumbing Fixtures.—All of the prices on plumbing fixtures on the following pages are net to the plumbing contractor.

Prices of Granitine Laundry Trays

Two part laundry trays, complete with swing spout faucet, drains, metal rims and angle frame. Size 48"x24", Price $50.00. Allow one plumber four hours for roughing in, four hours to set.

Three part laundry trays, complete with 2 swing spout faucets, drains, metal rims and angle frame. Size 72"x24", Price $82.60. Allow one plumber five hours to rough in, five to set.

Duraclay Laundry Tubs

Laundry tubs made of white, acid resisting vitreous glazed earthenware. Built-in washboard; soap depression. Chromium plated fittings with swinging spout with hose end. Twin wastes and stoppers. Single sink, size 22"x25", $69.00. Double sinks, size 42"x25", Price $138.00. Add $7.50 for stand. Allow one plumber four hours to rough in, four hours to set.

Electric Dishwashers

Many modern homes and apartments are now being equipped with electric dishwashers. These dishwashers may be installed as separate units or they may form a part of a complete sink.

The various units may be purchased at the following prices:

Dishwasher unit only with floor cabinet but without top and back-splasher, where used under a continuous counter top. Size 24"x25" and 34½ high. Price.....$225.00

Dishwasher unit with porcelain enamel top and back-splasher. Cabinets made of electrically welded rust-resistant steel with baked on enamel finish. Size 23"x27" and 39" high. Price...$250.00

Add installation charges to all of the above prices.

Garbage Disposal Units.—The disposal does away with the kitchen garbage can. It is a self-contained unit attached to the kitchen sink to form an enlarged drain into which all kitchen food wastes can be placed.

The unit consists of a housing in which is contained a propellor and shredding mechanism. A ¼ h.p. motor is directly connected to the propeller and shredding mechanism and supplies the power for operating the waste unit.

Waste material can be accumulated in the upper receptacle of the unit until a normal charge is collected or it may be operated to dispose of the material immediately. The capacity of the waste receptacle is 1 qt.

Waste material passes through a series of shredders where they are reduced to a fine pulp. This pulp then passes into a revolving strainer disc through which it is forced centrifugally into a chamber below and around the flywheel. Fins on the flywheel centrifugally force the pulp into the outlet passage connected to the drain line which carries the waste to the sewer. Cold water from the faucet flowing through the unit during the grinding operation thoroughly flushes the waste down the drain.

The price of this unit averages about $85.00.

Add installation charge to above price.

White (All-Clay) Porcelain and Vitreous China Urinals

Vitreous china urinal stalls extending to floor with integral flushing rim. Furnished with vitreous china urinal tank with automatic valve, ⅜" top supply and concealed hanger; flush pipe, brass stainers and with chromium or nickel plate. Furnished in batteries up to 4 urinals with one tank.

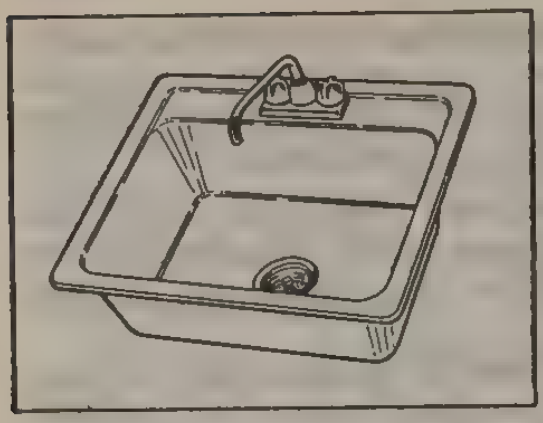
Width Inches	Single Unit	Battery of 2	Battery of 3	Battery of 4
18"	$131.00	$276.00	$406.00	$544.00

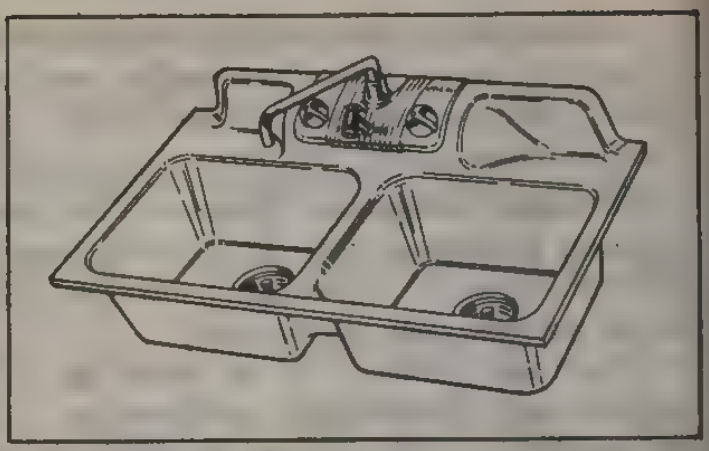
Allow five hours to rough in, four to set fixture.

Seam Covers for Urinal Stalls	Vitreous China 3"	6"
Plain seam covers, each	$20.00	$28.90

Wall hung urinals will run around $140.00 with flush valve and carrier.

Allow eight hours to rough in; four to set fixture.





Flat Rim Sinks

Single compartment flat rim sink. Acid resisting porcelain enamel on cast iron. Chromium plated supply trim with renewable controls mounted on extended back ledge. Chromium plated swinging spout. Receptor basket strainer with stopper and 1½" tail pieces. Size 24"x21"x8", Price.....$57.00
Size 30"x21"x8", Price..... 62.00

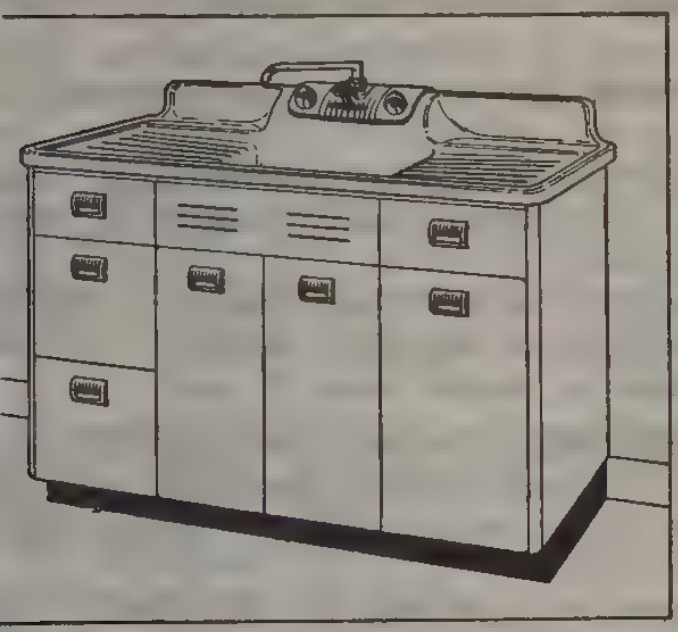
Allow four hours for roughing in, four hours for setting.

Two compartment flat rim sink. Same as described above for single compartment, except two compartments with removable strainer in each compartment. Overall size 32"x21"
Price $73.00
Size 42"x21", Price..... 95.00
Stainless steel mounting frame, Price..... 10.50

Allow six hours roughing in and six hours setting time.

Small Cabinet Sink.—Single drainboard and single compartment cabinet sink. Made of acid resisting porcelain enamel on cast iron. Chromium plated supply trim with renewable controls. Chromium plated swinging spout; 4" high back. Receptor basket strainer with stopper and 1½" tailpiece. Size 42"x25", basin 20"x18"x8".

rice, white sink less cabinet.....$100.00
rice, colored sink less cabinet..... 107.00



Medium and Large Cabinet Sinks.—One piece construction of acid resisting porcelain enamel on cast iron; double drainboards and single 8" deep basin; molded-in soap depression, chromium plated supply trim with renewable controls; chromium plated swinging spout; Receptor basket strainer with stopper and 1½" tailpiece. 4" high back.

ize 54"x25"x8", Price, white sink less cabinet.....$135.00
ize 60"x25"x8", Price, white sink less cabinet..... 140.00
ize 72"x25"x8", Price, white sink less cabinet..... 199.00
olored sink, 54"x25"x8", less cabinet, Price..... 146.00
olored sink, 60"x25"x8", less cabinet, Price..... 151.00
olored sink, 72"x25"x8", less cabinet, Price..... 217.00

SINK CABINETS

White Enameled Steel Deluxe Sink Cabinets

2" Sink .....Price $148.00
4" Sink .....Price 175.00
0" Sink .....Price 180.00
2" Sink .....Price 200.00

Steel Shower Compartments

Steel shower compartments are furnished in a variety of styles nd sizes, varying in price from $95.00 to $575.00 and more, de-ending upon the size, finish and accessories.

A medium priced shower stall made of bonderized galvanized teel, with white baked enamel finish, precast terrazzo receptor ith brass drain.

Furnished with concealed two-valve shower with metal lever

handles and ball joint shower head, soap dish, plastic curtain with hooks.

Size 32"x32"x81", price complete as described above.....$224.00

A lower priced shower stall of bonderized galvanized steel, with white baked enamel finish, slip-proof pre-cast stonetex receptor with drain.

Furnished with concealed two-valve shower with metal lever handles, and economy ball joint shower head, soap dish, translucent plastic curtain with rings.

Size 30"x30"x75", price complete as described above.....$95.20
Size 32"x32"x75", price complete as described above..... 98.40

Allow eight hours to rough in, twelve hours to set.

Porcelain Enamel Steel Bathtub.—Pressed steel tub with acid resisting porcelain enamel. Chrome plated renewable overrim supply fittings and pop-up waste and overflow. Width 30½", height 15½".

5'-0" tub, furnished complete with fittings as described above, white, $100.00; colors.....$120.00

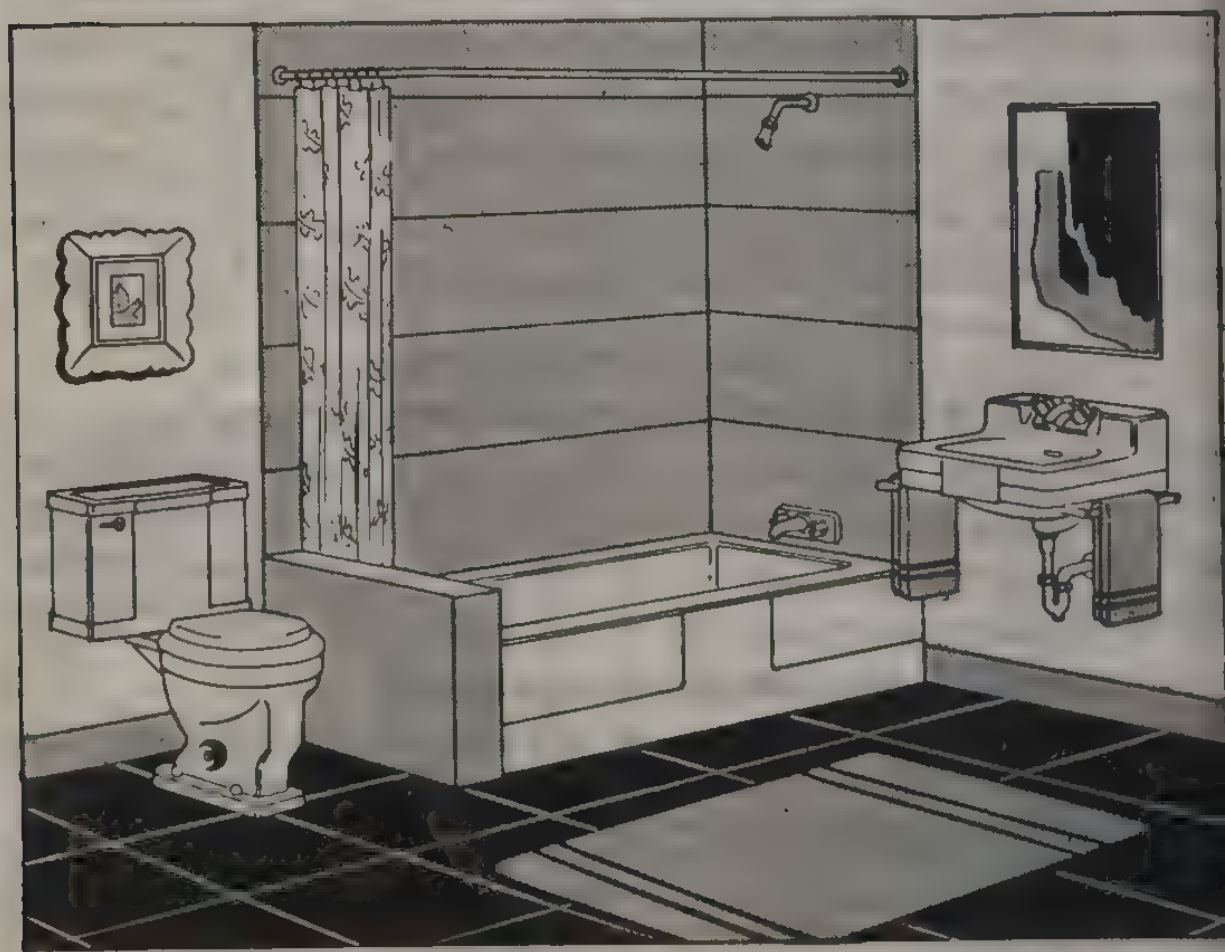


Fig. 1. Bathroom

For diverter overrim supply and shower fitting, add..... 11.00
Allow seven hours to rough in and seven hours to set tub. Add four more hours to rough in and set shower head.

Lavatory.—Porcelain enamel on cast iron; shelf back rectangular basin and soap depression. Chromium plated trim with renewable controls, mixing spout and direct lift waste.
Size 19"x17". Price, white $41.00. Colors.....$46.00
Size 24"x18". Price, white $44.00. Colors.....$51.00
If wanted with chromium plated legs, add..... 12.00
Allow six hours to rough in and four hours to set a lavatory.

Vitreous China Toilet.—Close coupled; whirlpool jet flushing action; sheet covered seat and cover. Regular rim. Price, white- $43.00. Colors.....$50.00
Allow eight hours to rough in and six hours to set a floor mounted closet and tank.

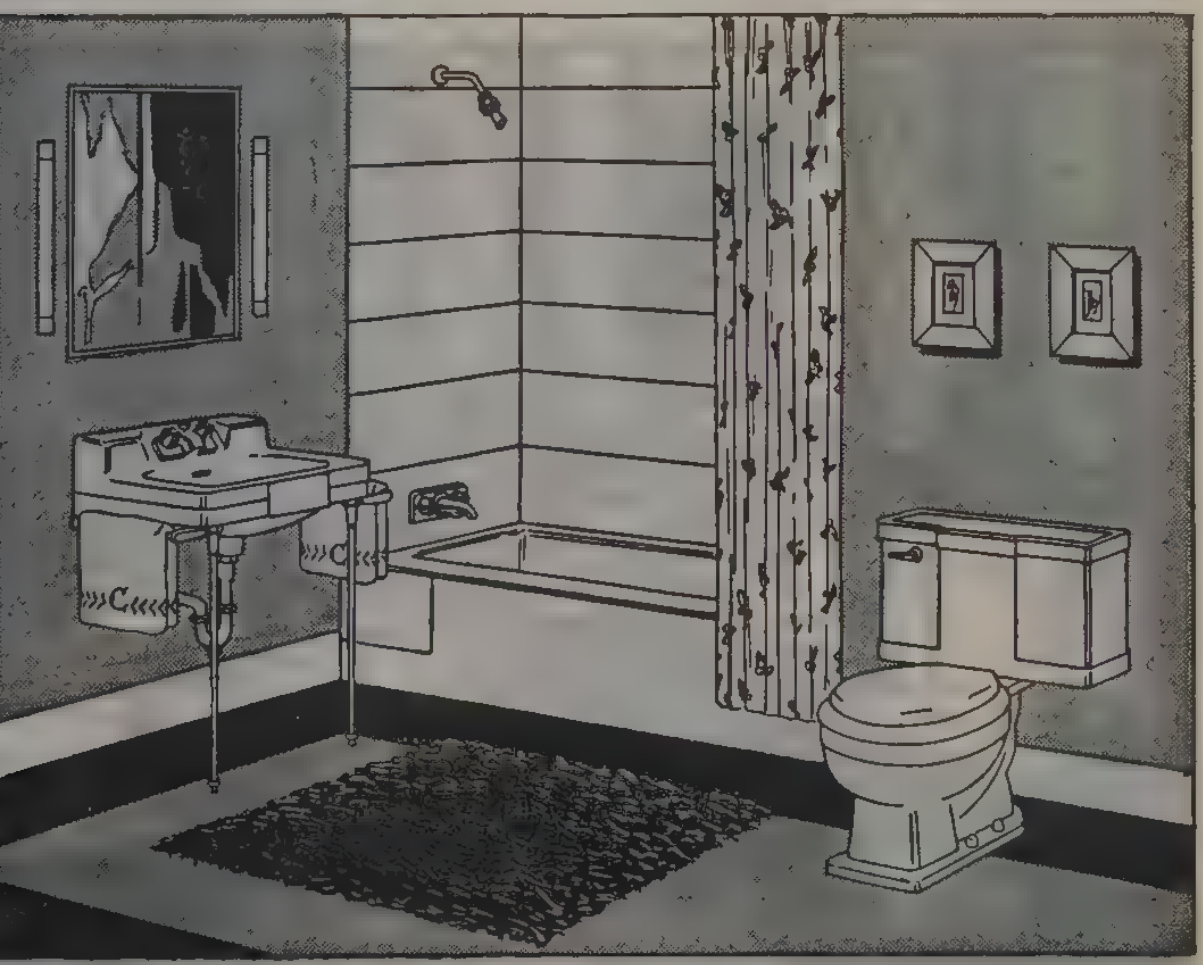


Fig. 2. Bathroom

Recess Bathtub.—Porcelain enamel on cast iron; flat bottom, 14" height and sloped end. Chromium plated trim with renewable controls. Pop-up drain. 4'-6" long. Price, complete with fittings $90.00
Diverter spout and economy shower head, add..... 11.00
For colored bathtub, add..... 7.00

Lavatory.—Vitreous china lavatory with shelf back, molded-in soap depression; chromium plated trim with renewable controls; direct lift waste, towel bars. Size 19"x17". Price, complete with fittings, white, $64.00; colored.....$69.00
Size 20"x14", complete as above, white $68.00; colors..... 83.00

Recess Bathtub.—Made of porcelain enameled cast iron with flat bottom and 14" high. Chromium plated trim with renewable controls, pop-up waste and overflow.
Price 4'-6" tub, complete with fittings as described above, white, $90.00; colors.....$97.00
For diverter spout and shower, add..... 11.00

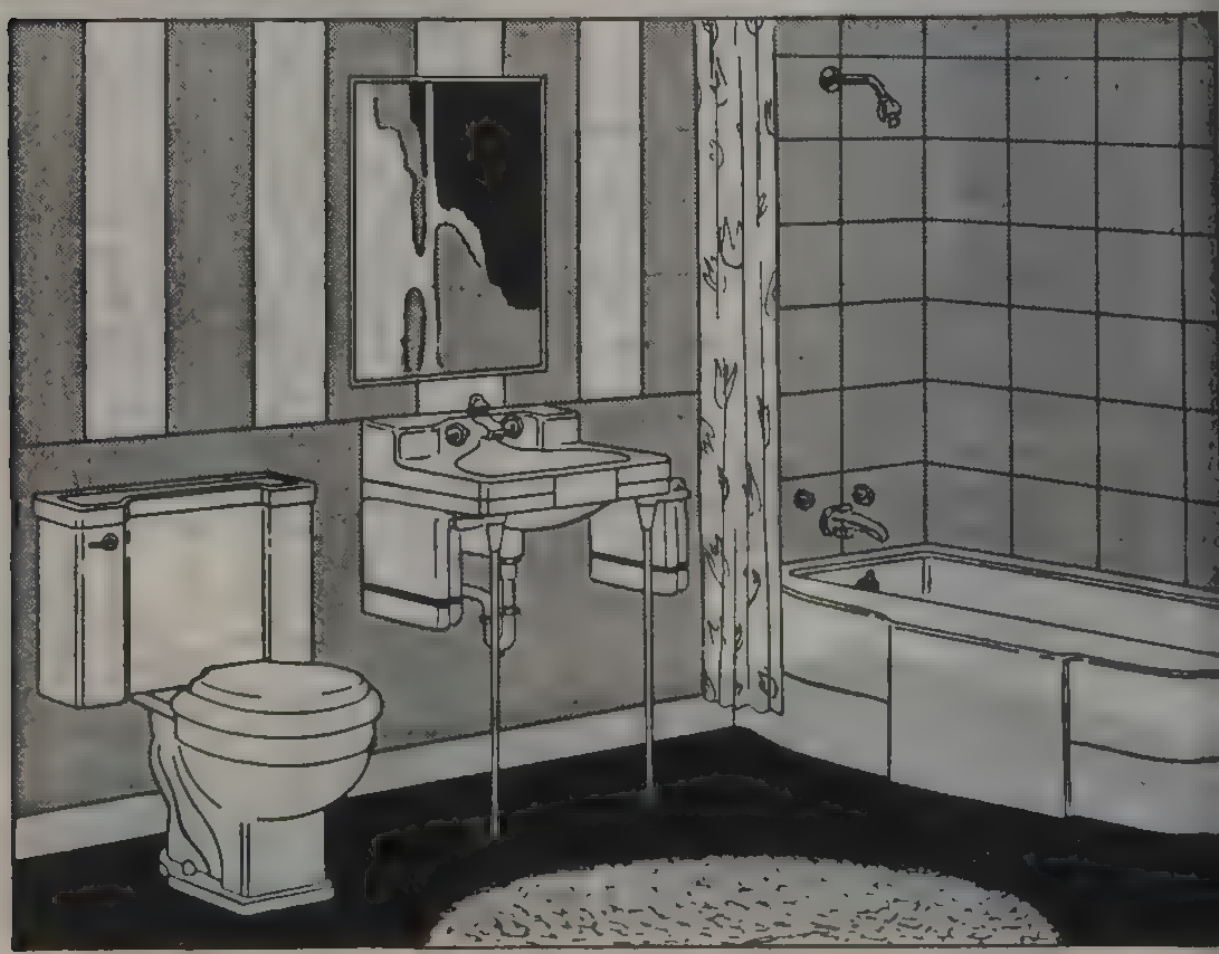


Fig. 3. Bathroom

Vitreous China Toilet.—Close coupled design, vitreous china toilet; whirlpool jet flushing action, plastic seat and cover, regular rim. Price.....$50.00
Colored toilet, same as above..... 61.00

China Lavatory.—White vitreous china lavatory with integral china spout; molded-in soap depression; raised shelf back: Chromium trim with renewable controls; chromium plated legs and towel bars.
Lavatory 22"x18", price, complete with fittings as described above, white $101.00; colored.....$124.00

Recess Bathtub.—White porcelain enamel on cast iron; broad rim seat, flat bottom and low height. Chromium plated trim with renewable controls. Pop-up waste and overflow.
Tub 5'-0" long. Price complete with fittings as described above, white, $123.00; colors.....$152.00
For 5'-0" corner tub, add approximately..... 27.00
For 5'-6" recess tub, add approximately..... 27.00
For diverter spout and shower head, add..... 18.00

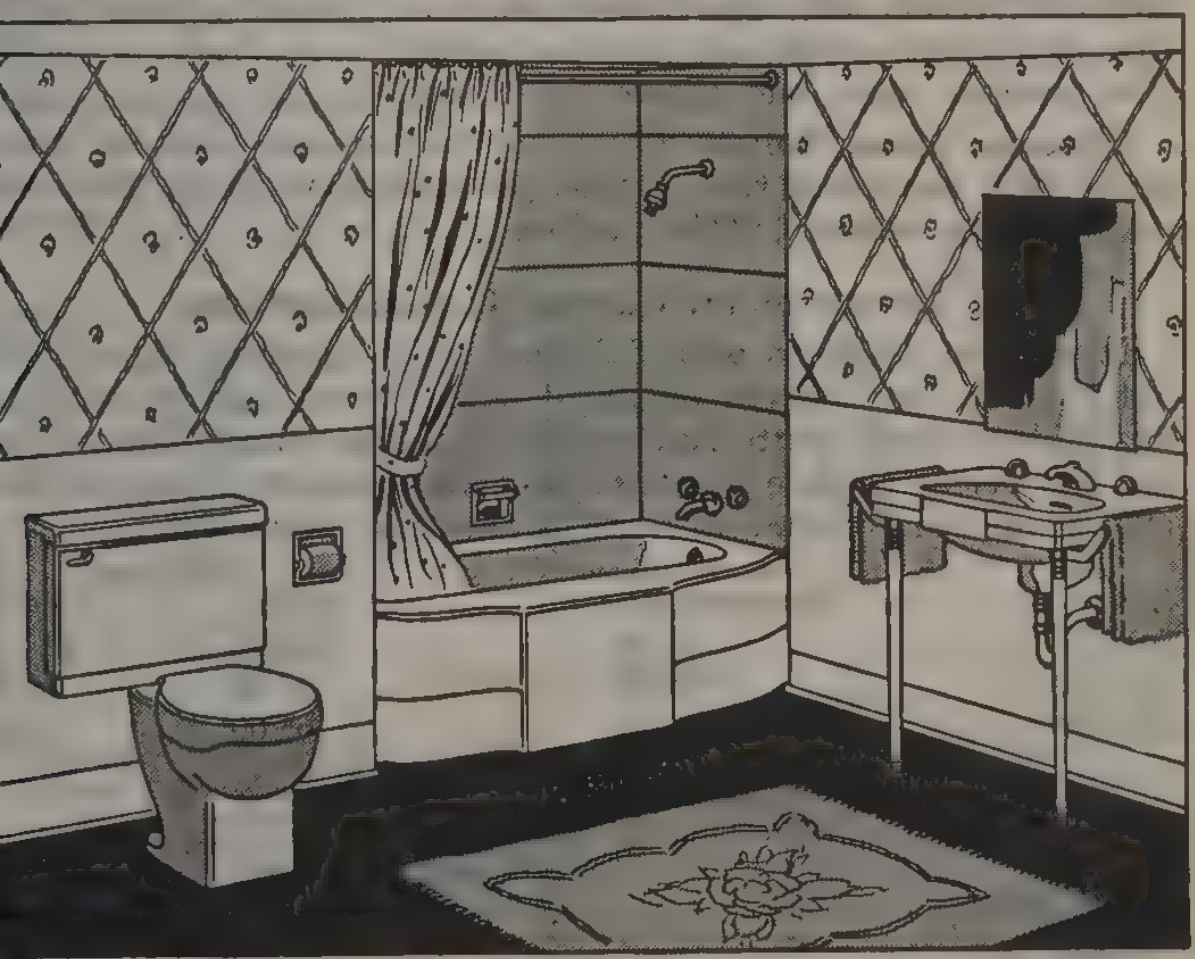


Fig. 4. Bathroom

Vitreous China Toilet.—Close coupled design, vitreous china closet; whirlpool jet flushing action. White sheet covered seat and cover. Regular rim. Price, white $70.55; colored.....$94.50
Same as above with integral rim bowl, white, $77.40; colored $103.60

China Lavatory.—White vitreous china lavatory with flat, smooth top. Chromium trim with renewable controls; quick draining, lever-action waste; chromium plated legs.
Size 21"x18". Price complete with fittings as described above, white, $163.00; colors.....$194.00
Size 30"x22". Price complete with fittings as described above, white, $195.00; colors..... 242.00

Recess Bathtub.—White porcelain enamel on cast iron; broad rim seat, flat bottom and low height. Chromium plated bath and shower trim with renewable controls. Pop-up waste and overflow. 5'-0" long.
Tub 5'-0" long. Price complete with fittings as described above, white, $123.00; colors.....$152.00
For corner tub, add approximately..... 27.00
For 5'-6" recess tub, add approximately..... 27.00
For diverter spout and shower head, add..... 18.00

Vitreous China Toilet.—Close coupled design, vitreous china toilet with elongated rim; siphon jet whirlpool action. Seat and cover. Price, white, $129.00; colors.....$175.00

Lavatories for Counter Top Installations

Lavatories designed with flat rims and projecting edges on all sides to fit into custom designed counter and cabinet tops are available in both white and colored vitreous china. The following list prices include the vitreous china lavatory complete with chromium trim, renewable controls and lever action waste.

Size	Price of Hudee Aluminum Frame	List Price White	List Price Colored
20"x19"	$5.50	$40.75	$51.15
24"x21"	5.50	47.90	58.00
27"x20"	9.00	65.00	89.00

Wall Hung Tank Toilets

	Prices White	Prices Colored
Reverse Trap	$ 58.00	$ 72.00
Siphon Jet	116.00	160.00

For carrier for residential type toilet add $32.00.

Vanity Units

Complete with wood factory finished cabinet plastic top, bowl nd faucets.

24"	$70.00
30"	85.00
36"	95.00

Industrial Wash Fountains

	Circular		Semi-Circular	
	54"	36"	54"	36"
Precast Stone	$285.00	$220.00	$265.00	$210.00
Vitreous Enamel	325.00	240.00	285.00	225.00
Stainless Steel	415.00	280.00	380.00	270.00

It will take two plumbers to set these fixtures. 15 hours total hould cover roughing in and setting.

Automatic Water Heaters—Made with fiberglass insulation, nameled steel outer jacket, and 100% automatic safety controls. Prices are dealer prices.

Gas Heaters

Capacity Gals.	Overall Dia.	Overall Ht.	Approx. Wt.	Prices 5 Year	10 Year
20	14½"	61"	144 Lbs.	$53.00	$ 75.00
30	16¼"	64"	174	55.00	90.00
40	18½"	65"	195	62.00	105.00
50	20¼"	65"	274	79.00	120.00
75	24 "	67"	360	—	250.00

Electric Heaters

Capacity Gals.	Overall Dia.	Overall Ht.	Approx. Wt.	Prices 10 Yr.
40	20	50	160	$ 83.60
52	23	50	181	93.45
66	23	62	227	116.90
82	25	63	270	131.60
110	28	69	430	194.55

KITCHEN EQUIPMENT

(Prices are dealer prices)

	Price Range, Gas	Price Range, Electric
Ranges:		
Standard type	$140.00-$250.00	$160.00-$275.00
Drop-in type		100.00- 200.00
Built-in type		
Surface burner	$ 65.00- 70.00	65.00- 100.00
Oven	150.00- 220.00	150.00- 295.00
Refrigerators (freezer compartment)		
8 cu. ft. capacity		120.00- 200.00
9½ " " "		150.00- 300.00
12½ " " "		250.00- 375.00
Upright Freezer 9.5 cu. ft.		200.00- 250.00
Laundry Equipment		
Dryer	140.00- 250.00	110.00- 200.00
Washer		175.00- 275.00
Combination washer dryer.		300.00- 470.00

CHAPTER XXX

ELECTRIC WIRING

Electricity plays an increasingly more important role in construction each day. Some buildings towering 50 stories or more are completely dependent upon electricity, not only for light, power, and building services, but for completely electrified tenant equipment and sometimes heat. Heating and lighting are dependent upon each other so that a maximum use of electric energy may be obtained at a minimum of expense.

Obviously such sophisticated designs are well beyond the scope of this book. But even a modest residence will involve electrical planning and power demands well beyond anything thought of 5 years ago.

For very preliminary estimates, electrical work can be assumed to run from 4 to 5 percent of the total job cost for residences, 5 to 7 percent for office buildings, and 8 to 12 percent for industrial building. Often small jobs are roughly figured at so much an outlet, usually around $12 to $15, to which must be added the cost of service in (from $200 to $300) and all special outlets which require power wiring which will run around $40 for light appliance outlets and $80 for heavy appliances.

In order to obtain accurate costs and to check actual installation costs, an estimator should make a detailed electrical take off. The estimator must then have a thorough knowledge of the working drawings and specifications from which the job will be built as well as the building code under which it will be inspected, and also regulations set by the local utility company.

A rotometer which will scale distances directly off the drawings is handy if drawings include sufficient interior room elevations so that not only horizontal but vertical distances may be measured.

The electrical take off sheet should have a column for each of the following:

1. Ceiling outlets
2. Bracket outlets
3. Duplex convenience outlets
4. Triplex convenience outlets
5. Waterproof convenience outlets

6. Range outlets
7. Lighting outlet with lampholder
8. Special purpose outlets (dishwashers, clothes dryers, etc.)
9. Single pole switches
10. Three-way switches
11. Length of wiring.

The estimator then should check off each item and enter the total on the sheet. This is best done floor by floor or, in large one-story residences, wing by wing, so that checking and changes ordered on the job will be simplified.

Enter next the circuit and feeder control centers, listing them by type and size, and then the branch circuits. As mentioned above, a rotometer will be helpful in measuring raceway runs, but be sure all drawings used are at the same scale. List separately two-wire and three-wire runs and empty conduit for telephones and such other special items as intercoms, buzzer systems, television outlets, and the like.

A final list of such items as fixture hangers, studs, locknuts, bushings, cable clamps and outlet covers will complete the take off; then all these items can be transferred to the pricing sheet item by item.

A pricing sheet should include a line for each type of item; the quantity involved; the material cost by unit and in total; the hours estimated for installation per unit and hourly rate; the total labor cost and, finally, the total labor and material cost.

Service Entrance Equipment

The service entrance equipment consists of the service drop, service entrance conductors, the meter, main control center, and the service ground. The local utility will govern the details of this installation and may or may not furnish the meter. Underground service is highly desirable and may be required by local ordinances. Underground service for residential use will run around $5.00 per lineal foot. Overhead lines will run around $250 per pole. The main control center for residential work will consist of a circuit breaker-fuse panel of at least 100 amp. capacity.

Safety Switches

Capacity	Cost	Hours to set
100 amp. 3 pole, gen. purpose	$ 70.00	4
200 amp. 3 pole, gen. purpose	90.00	7
400 amp. 3 pole, gen. purpose	220.00	10
600 amp. 3 pole, gen. purpose	350.00	13

Conduit

Rigid conduit is seldom used in residential work today, although it still offers the most flexible and safest system and, in some large cities, is required by code. Rigid systems may be galvanized steel, aluminum or electric metallic tubing, generally referred to as "thinwall".

Material Costs and Labor to Set 100 Lin. Ft. of Rigid Conduit

Size	Galvanized Cost	Galvanized Hours to Set	Aluminum Cost	Aluminum Hours to Set	EMT Cost	EMT Hours to Set
½"	$ 18.00	12	$ 18.00	10	$ 8.00	8
1"	34.00	14	33.00	12	16.00	10
1½"	53.00	18	53.00	16	25.00	14
2"	70.00	20	71.00	18	33.00	16
3"	145.00	28	155.00	24	—	—
4"	220.00	36	225.00	32	—	—

Material Cost and Labor to Set Fittings for Rigid Conduit

Size	Cost of Galv. Ell & Cpl.	Hours to Set	Cost of Alum. Ell & Cpl.	Hours to Set	Cost of EMT Ell	Hours to Set
1½"	$ 1.40	.75	$ 1.50	.5	$0.70	.6
2"	2.45	1	2.20	.75	1.20	.75
3"	7.20	1.5	7.00	1.25	—	—
4"	16.00	2.5	17.00	2.00	—	—

Couplings for EMT "thinwall" will run 12¢ ea. for ½", 25¢ for ", 60¢ for 1½" and 75¢ for 2".

Flexible conduit, or as it is often referred to, "Greenfield," is easier to install.

Material Cost and Labor to Install 100 Lin. Ft. of Flexible Conduit

Size	Conduit Cost	Connector Cost	Labor to Set
½"	$ 17.00	$0.22 each	6 Hrs.
1"	42.00	.40	7
1½"	65.00	1.20	10
2"	92.00	1.80	14
3"	140.00	5.10	18

Where codes allow the least expensive methods of wiring are rewired armored cable (BX) or non-metallic sheathed cable such s Romex.

Material Cost and Labor to Install 100 Lin. Ft. of Armored Cable

Gauge of Wire	No. of Wires	Cost	Labor to Set
# 10	2	$18.50	5 Hrs.
# 10	3	25.00	6
# 12	2	11.00	4
# 12	3	15.50	5
# 14	2	8.20	4
# 14	3	11.50	5

Material Cost and Labor to Install 100 Lin. Ft. of Non-Metallic Sheathed Cable with Ground

Gauge of Wire	No. of Wires	Cost	Labor to Set
# 12	2	$10.00	3
# 12	3	17.00	3.5
# 14	2	7.80	2.5
# 14	3	14.00	3

Cost and Labor to Set Boxes

Size	Cost	Labor to Set
4x3	$1.15	.4
2 Gang	1.50	.5
4 Gang	2.45	1
6 Gang	4.00	1.25
4" Octag.	.38	.4

Duct System

Underfloor metal duct systems vary widely in their complexity. Some floor systems have raceways built in, others are added in the floor fill and may be a one or two level system. Standard duct is 1-¼"x3-⅛" and has an area of 3.75 sq. in. Super duct is 1-½"x6-⅛" and has an area of 8.9 sq. in. Lengths are 5', 6', 10' and 12'. Detailed take offs on these systems are beyond the scope of this book. The Square D Company catalog gives a suggested take off method with all the required fittings. For budget figures a simple underfloor duct complete with fittings and wiring will run around $9.00 per lineal foot.

Material Cost and Labor to Set 100' of Fiber Duct

Size	Duct Cost	Labor to Set	Coupling Cost	Labor to Set
2	$28.00	8	$ 3.00	.4 Hrs.
3	32.00	10	4.50	.6
4	42.00	14	6.00	.75
6	83.00	28	12.00	1.5

Wire and Cable

Material Cost and Labor to Pull 100 Lin. Ft. of Wire in Conduit Already in Place (600 V Type RHW; 3 Wire)

Gauge	Material Cost	Hours to Pull
14	$ 16.00	4
12	20.00	5
10	25.00	6
8	36.00	7
6	51.00	8.5
4	65.00	9
2	95.00	11
1/0	150.00	14
2/0	175.00	18
4/0	270.00	22

Switches and Receptacles

An electrician should set four single pole switches per hour and ree double pole, 3 or 4 way switches per hour.

Cost of Toggle Switches

Grade	Type	Amps.	Cost*
Intermediate	Single Pole	10	$0.75
	Double Pole	10	1.15
	3 Way	10	1.00
	4 Way	5	2.60
Specification	Single Pole	10	1.20
	Double Pole	10	2.00
	3 Way	10	1.50
	4 Way	5	4.40
Specification	Single Pole	15	1.10
	Double Pole	15	1.65
	3 Way	15	1.50
	4 Way	15	3.70
Mercury	Single Pole	5	.85
	Double Pole	5	1.50
	3 Way	5	1.45
Mercury with Lighted Handle	Single Pole	5	1.20
	3 Way	5	1.80
Door Switch		5	5.25

*Add 5¢ per unit for ivory handles.

Cost of Receptacles per 100

15 Amp 125V Single	$ 51.00
15 Amp 125V Duplex	65.00
15 Amp 125V Single Twist	53.00
15 Amp 125V Duplex Twist	70.00
15 Amp 125V Single 3 Wire	125.00
15 Amp 125V Duplex 3 Wire	228.00
20 Amp 250V Single	175.00
30 Amp 250V Single	205.00
50 Amp 250V Single	205.00

Figure setting four receptacles an hour for 15 amp units, three per hour for 20 and 30 amp units, and 45 min per unit for 50 amp receptacles.

Cost of Switch and Receptacle Plates per 100

Description	Cost in Phenolic	Cost in Brass	Cost in Stainless
1 Gang Switch	$ 8.00	$ 45.00	$ 44.00
2 Gang Switch	16.00	90.00	85.00
3 Gang Switch	34.00	133.00	120.00
4 Gang Switch	60.00	177.00	150.00
1 Gang Outlet	8.00	45.00	44.00
2 Gang Outlet	47.00	126.00	85.00
3 Gang Outlet	. . . .	198.00	. . . .
Blank-Single	20.00	58.00	53.00
Telephone	20.00	62.00	54.00

Weatherproof switches with grey Hypalon presswitch plates will run $171.00 a hundred.

Lighting Fixtures

The following is a sampling of some fixtures an electrician might encounter on average work.

Type	Wattage	Size	Shielding	Cost
Industrial Fluorescent	2-40	4′	Open	$ 22.00
	4-40	8′	Open	44.00
	2-40	4′	Louvers	24.00
	4-40	8′	Louvers	48.00
Commercial Fluorescent	2-40	4′	35°x35°	21.00
Surface Mounted	4-40	4′	35°x35°	30.00
Average Quality	4-40	8′	35°x35°	39.00
	8-40	8′	35°x35°	60.00

Lighting Fixtures—Continued

Type	Wattage	Size	Shielding	Cost
ommercial Fluorescent				
Surface Mounted,	2-40	4′	Acrylic	$34.00
Premium Quality	4-40	8′	Acrylic	63.00
ommercial Fluorescent	2-40	4′	Holophane	38.00
Recessed Troffers	4-40	8′	Holophane	70.00
ommercial Fluorescent	4-20	2x2	Acrylic	40.00
Square Surface	6-30	3x3	Acrylic	85.00
	6-40	4x4	Acrylic	100.00
ommercial Fluorescent				
Corridor Unit	1-40	4′	Acrylic	20.00
candescent Industrial	1-100	12″ diam.	Open	2.70
Dome Bowl	1-150	14″ diam.	Open	3.25
	1-200	16″ diam.	Open	3.75
	300-500	18″ diam.	Open	4.75
	750-1000	20″ diam.	Open	7.00
igh Bay Mercury	400-1000	24″ diam.	Open	30.00

ommercial Incandescent			
Recessed Fixed Spot	150w	10″ diam. Open	9.00
Adj. Spot	150w	10″ diam. Open	13.00
Punch Spot	150w	8″ diam. Open	12.00
Recessed Square	100w	8x8 Opal	10.50
Alum. Wall Bracket	75w	5″ diam. Glass	12.00
Pendant Metal Shade	100w	11″ diam. Glass	15.00
Pendant Sphere	40w	16″ diam. Glass	35.00
Pendant Sphere	375w	16″ Opal	10.00
Drum	100w	18″ Opal	21.00

For Stems add: 6″ Drop $1.35
18″ Drop 1.50
30″ Drop 2.00

For plaster rings for spots add $1.20.

Electrical Heating

Heating electrically includes a broad range of methods—radi-nt units, convector units, baseboard units, radiant systems em-dded in building structure, electric furnaces with forced air, nd heat pumps with forced air. Some of these methods are often cluded as simple supplemental heaters; others are full plants nd involve quite sophisticated design in order to function most ficiently.

Wall heaters are the simplest, most commonly encountered means of heating electrically. Both natural and fan driven units are available and they are usually recessed and have built in thermostats. A 1500 watt ceiling fan unit will cost around $50; a 1500 watt ceiling radiant unit around $35; a 1000 watt ceiling radiant unit, $20. A 1200 watt fan forced unit will run $24 with manual control, $26 with thermostat.

Baseboard heaters are available in standard and high wattage models in surface mounted and semi-recessed designs. The wiring serving these units may be part of the common wiring system or fed from separate branch control centers.

In some areas electricity for heating is separately metered and must be on a separate system. For preliminary figures, baseboard units will run around $18 a lineal foot installed, but not including separate wiring system. Add $15 for each thermostat. Baseboards, if used as the sole heating source, are usually supplemented by fan units at entrances.

Radiant heating embedded in building construction may be cables installed in plaster or between layers of gypsum board or may be factory embedded in gypsum board. Cable is stapled to the lath. Individual rooms each may have their own thermostat. No heating source is visible. This system must be carefully engineered.

Electric furnaces are similar to conventional warm air furnaces but substituting electric resistance-heating units for flame. They are very compact, require no flue or vent and can be placed anywhere so zone heating is simplified. Also, air cooling systems can be added to provide a year 'round system. A variation on this are through-the-wall units including both heating and cooling capacities. These are especially suitable for motels, dormitories and other similar buildings where individual control is important.

Heat pumps are designed to utilize existing outside conditions to supplement inside heating and cooling. That is, in the winter it extracts heat from outside air, ground or water and conducts it to the inside and, in summer, removes heat from base to the outside. It is most generally placed outside to eliminate noise. Units are usually designed to handle air cooling loads. In areas of extreme cold where heating capacity of pump is inadequate, it is supplemented by electric resistance heaters. The unit is connected to a duct system within the house.

CHAPTER XXXI

REHABILITATION AND REMODELING WORK IN RESIDENTIAL BUILDINGS.

Remodeling work poses many problems for the estimator not found in new work, but it can be quite profitable, can lead to new clients and future work, and can provide the small carry-over jobs needed at times to keep crews busy during bad weather or slack periods.

The following suggestions for estimating concern themselves with items encountered in smaller remodeling work. But even here the estimator must be aware of all the job conditions and should investigate and make allowances for them, including:

a) Need for protecting adjacent work.
b) Removal of rubbish and/or salvage.
c) Restrictions during normal working hours.
d) Extent of daily cleaning up involved.
e) Is there enough work to keep the various trades busy for a full day's work or will there be call backs for only fractional periods?
f) Will owner be constantly supervising work?
g) Are plans of original structure available which will show mechanical and structural details to be encountered?
h) Is work governed by a strict building code which might require work beyond that immediately ordered, such as strengthening structural members, adding additional exits to a remodeled 3rd floor, etc.?
i) Do you have men available who can form a cooperative team as there are almost always changes from plans to be made to fit actual job conditions as they are uncovered.

Masonry Repairs

Cutting Out Mortar Joints.—Using a carborundum wheel 5" in diameter and ¼" thick for a cut to a depth of ½", the following cost per 100 sq. ft. may be assumed:

	Hours	Rate	Total	Rate	Total
Tuckpointer	2	$....	$....	$7.50	$15.00
Helper	1	....	....	5.00	5.00
Cost per 100 sq. ft.	3		$....		$20.00
Cost per sq. ft.					.20

On multi-story buildings, scaffolding and sidewalk protection costs often have to be added.

Repointing Mortar Joints in Old Brick.—After the mortar joints have been cut out, two tuckpointers working on the scaffold with one helper on the ground should point 400 to 500 sq. ft. of brick wall per 8 hour day at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Tuckpointers	3.5	$....	$....	$7.50	$26.25
Helper	1.5	....	....	5.00	7.50
Cost per 100 sq. ft.	5.0		$....		$33.75
Cost per sq. ft.					.34

Removal of Brick by Hand Chipping.—A mason should hand chip around 200 pieces per 8 hour day at the following labor cost per 100 pieces:

	Hours	Rate	Total	Rate	Total
Mason	4.5	$....	$....	$7.10	$31.95
Helper	1.0	....	....	5.00	5.00
Cost per 100 pieces	5.5		$....		$36.95
Cost per brick					.37

Removal of Brick by Pneumatic Pick.—Where larger areas of brick masonry are to be broken out, two laborers working with a pneumatic pick can be figured. For each 100 sq. ft. of 12" thick wall, figure as follows:

	Hours	Rate	Total	Rate	Total
Labor	18	$....	$....	$5.00	$ 90.00
Pick Rental		....	....	30.00	30.00
Cost per 100 sq. ft.			$....		$120.00
Cost per sq. ft.					1.20

Removal of Concrete Block.—Block walls can usually be knocked down manually by laborers. For 12" or 8" block walls, figure per 100 sq. ft. as follows:

	Hours	Rate	Total	Rate	Total
Labor	8	$....	$....	$5.00	$40.00
Cost per sq. ft.					.40

To remove 4" partition block, figure per 100 sq. ft. as follows:

	Hours	Rate	Total	Rate	Total
Labor	4.5	$....	$....	$5.00	$22.50
Cost per sq. ft.					.23

Removing Gypsum Tile.—Gypsum tile partitions will go even faster. Per 100 sq. ft. can be figured as follows:

	Hours	Rate	Total	Rate	Total
Labor	2.5	$....	$....	$5.00	$12.50
Cost per sq. ft.					.13

Where bearing walls are cut through, it will be necessary to provide needling and shoring, and to set in a new lintel. A 3′ wide opening in an 8" wall will cost about $80.00 to shore and another $40.00 to build in lintels. A 6′ wide opening will cost about $100.00 to shore and $50.00 to set a beam for a lintel.

To Patch Face Brick.—To patch 4" face brick, figure one mason and one helper can lay about 65 sq. ft. per day.

Labor Cost per 100 Sq. Ft.

	Labor	Rate	Total	Rate	Total
Mason	12	$....	$....	$7.10	$ 85.20
Helper	12	....	....	5.00	60.00
			$....		$145.20
Labor cost per sq. ft.					1.45

Material cost per sq. ft. will add another 60¢.

To Patch Common Brick.—Where openings are closed up or otherwise patched out in small areas, one mason and one helper should lay about 30 cu. ft. of common brick per day.

Labor Cost to Patch 100 Sq. Ft. of 12" Common Brick Wall

	Hours	Rate	Total	Rate	Total
Mason	27	$....	$....	$7.10	$191.70
Helper	27	....	....	5.00	135.00
			$....		$326.70
Cost per sq. ft.					3.27

Material cost per cu. ft. will add another $1.30.

To Patch Concrete Block Partitions.—One mason and a helper should patch out 150 sq. ft. of 4" block partitioning per day.

Labor Cost to Patch 100 Sq. Ft. of 4" Block Partitioning

	Hours	Rate	Total	Rate	Total
Mason	5.5	$....	$....	$7.10	$39.05
Helper	5.5	....	....	5.00	27.50
			$....		$66.55
Cost per sq. ft.					.67

Material costs will add about 24¢ per sq. ft.

To Patch Gypsum Tile Partitioning.—One mason with a helper will patch about 200 sq. ft. of 4" gypsum tile partitioning per day.

Labor Cost to Patch 100 sq. ft. of 4" Gypsum Tile

	Hours	Rate	Total	Rate	Total
Mason	4	$....	$....	$7.10	$28.40
Helper	4	....	....	5.00	20.00
			$....		$48.40
Cost per sq. ft.					.48

Material costs will add about 30¢ per sq. ft. Add another $1.00 for patching plaster on both sides of gypsum tile.

To Rebuild Chimneys.—On small chimneys one mason with a helper will lay about 500 bricks per day.

To Build in New Glass Block Panels

Cost of 100 Sq. Ft. of Nominal 8x8x4 Glass Block

	Hours	Rate	Total	Rate	Total
230 Glass Blocks		$....	$....	$1.08	$248.40
3.6 Cu. Ft. Mortar		....	....	1.04	3.74
Mason	15.0	....	....	7.10	106.50
Helper	7.5	....	....	5.00	37.50
Labor On Scaffolding	2.0	....	....	5.00	10.00
30 Lin. Ft. Expansion Strip		....	....	.12	3.60
½ Pt. Asphalt Emulsion		....	....	.60	.15
Carried Forward			$....		$409.89

Cost of 100 Sq. Ft. of Nominal 8x8x4 Glass Block—Continued

	Hours	Rate	Total	Rate	Total
Brought Forward		$....	$....	$....	$409.89
lbs. Oakum		....	....	0.30	0.60
Gal Caulking		....	....	6.00	2.25
Mason Caulking	1.5	....	....	7.10	10.65
Mason Cleaning	2.5	....	....	7.10	17.75
Cost Per 100 Sq. Ft.	28.5		$....		$441.14
Cost Per Sq. Ft.					4.41

To this must be figured the cost of making the opening or removing the existing window and the cost of patching window returns, where frame and trim have been removed.

To Add Nailon Brick to Existing Walls.—1" thick ceramic units formed to the size of standard and Norman bricks may be applied over any nailable surface such as plywood, wood sheathing, furring strips and various types of concrete and masonry. One sq. ft. of wall will require 6 of the standard units which cost $90.00 per 1000 in red, $99.00 in golden blend and $112.50 in gray. On small jobs one mason (check local jurisdiction on this, as it varies) working alone should install around 700 standard units per 8 hour day. Mortar requirements are 1-½ cu. ft. per 100 sq. ft. of wall and a tuckpointer working alone should point about 450 standard units a day.

Special units are available for corners.

Cleaning and Pointing Face Brick.—Cleaning of large areas of brickwork is usually sublet to a contractor specializing in this work. For smaller jobs using brick masons, a man should clean and wash with muratic acid 4,000 to 4,500 smooth brick (600 to 675 sq. ft. of wall surface) per 8 hour day at the following labor cost per 1,000 brick or 150 sq. ft. of wall:

	Hours	Rate	Total	Rate	Total
Mason	2	$....	$....	$7.10	$14.20
Helper	1	....	....	5.00	5.00
Cost per 1,000 brick			$....		$19.20
Cost per sq. ft. of wall					.128

Rough brick will require about one-third more labor or will cost about 17¢ per sq. ft. of wall.

SIDING

To determine siding costs, it is best to sketch an outline of each elevation. For straight walls multiply the width by the height

and deduct from the total the combined square foot area of the doors and windows. Gable areas are found by multiplying the width by the height and dividing by two. Deduct window openings. Wall areas for dormers can be figured from the following table, the window areas being already deducted.

Side Wall Area for Dormers

Dormer Width	Type Of Dormer		
	Lift Type	Gable Type	Hip Type
5′-0″ (One Window)	88 Sq. Ft.	60	52
6′-0″	94	70	58
7′-0″	100	80	64
8′-0″ (Two Window)	88	70	52
9′-0″	94	75	58
10′-0″	100	85	64
11′-0″	106	90	70
12′-0″ (Three Window)	93	80	57

Add the net square feet of each elevation, gable and dormer together, add 8% for waste and figure to the nearest larger half or full square or nearest bundle of shingles for material costs.

Old siding may be stripped off before new is applied, or may be covered over either by applying an underlayment board or by applying wood stripping and felt over present siding. Underlayment board would figure the same quantity as siding. Wood stripping can be figured per square, depending on the exposure of existing siding, as follows:

Exposure in inches	4″	4½″	5″	5½″	6″	6½″	8″
Lin. ft. of stripping req'd.	300	280	240	224	200	188	152

For corners, use full height for metal corners. For corner boards figure one 3″ and one 4″ board for each corner. Add molding, flashing and caulking costs at doors and windows.

Labor Cost Per Square, Asbestos Shingles and Clapboards Applied with Wood Stripping

Size	Type	No. of Pcs./Sq.	Carpenter Hours
12″x24″	Shingle	57	2.66
8″x24″	″	93	3.5
9½″x8′	Clapboard	19	2.66

To prepare surfaces for new siding.

To Remove Existing Stucco, per 1,000 Sq. Ft.

	Hours	Rate	Total	Rate	Total
Labor	1.25	$....	$.....	$5.00	$6.25

To Add Sheathing Over Existing Boards, Per 100 Sq. Ft.

	Hours	Rate	Total	Rate	Total
105 Sq. Ft. Sheathing		$....	$....	$0.018	$ 1.89
1 lb. Nails		....	....	.15	.15
Carpenter	1.0	....	....	6.75	6.75
Helper	.3	....	....	5.00	1.50
110 Sq. Ft. Felt		....	....	.008	.88
Carpenter	.4	....	....	6.75	2.70
Cost Per 100 Sq. Ft.	1.7		$....		$13.87
Cost Per Sq. Ft.					.14

Corner Boards and Beads

Allow one-half hour of carpenter's time to set one 1x3 and one 1x4 corner per story. Beads will take approximately the same time.

CAULKING

When the space between the door and window frames and a masonry wall are caulked with oakum, an experienced man should caulk 340-400 lin. ft. of opening per 8 hour day at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Caulker	2.1	$....	$....	$6.75	$14.18
Cost per lin. ft.					.142

Where it is not necessary to pack in oakum, one man using a pressure gun should do about 600 lin. ft. per 8 hour day at the following labor cost per 100 lin. ft.

	Hours	Rate	Total	Rate	Total
Caulker	1.33	$....	$....	$6.75	$8.98
Cost per lin. ft.					.09

For caulking around doors and windows nothing smaller than 3/8" nozzle should be used. One gallon will caulk about 150 lin. ft. with a 3/8" nozzle, 100 lin. ft. with a 1/2" nozzle. Mastic caulking compound costs from $4.00 to $6.00 per gallon.

To Replace Fascia Boards.—Costs per lineal foot including material and labor, in pine:

1x4 $0.40	1x6 $0.50	1x12 $0.82	3 pc. $1.75

To Add Weatherstripping.—Lineal foot cost of material weatherstrip for double hung windows will average as follows in zinc:

Descriptions	Thickness		
	1-3/8"	1-3/4"	2-1/4"
Side, head & sill strips	$0.13	$0.16	$0.22
Meeting rail strips	.33	.35	.54

Bronze will run about 75% more.

Single or double casement windows that swing in require a ¾" wide track strip on the hinged side, running in a grove in the sash. At the top, on the latch side, and where the sash meet, if in pairs, interlocking hook and flat strips are generally used. A trough strip and a hook strip is generally used at the bottom of the sash. Material for jambs, head and center stiles will cost 13¢ to 16¢ per lin. ft. Brass trough section and interlocking still strip, $1.40 per lin. ft. Sill strips for outswinging casements will cost about 60¢ per lin. ft.

Weatherstrips for single wood doors in spring bronze will range from $8.00 to $9.00 per opening, including a brass threshold. Aluminum thresholds will run about $2.00 less. If interlocking bronze rather than spring type is used, add $3.00 to the above figures. Extruded aluminum and neoprene spring stop mounted strips run $1.00 per foot for 1-⅛" x ¼" and $2.40 per foot for 1-¼"x⅝". Bottom rail gasket runs $1.35 per foot.

Labor Installing Weather Strips

	Hours
1⅜" D. H. sash to 3x5'6"	0.9
1¾" D. H. sash to 4x7	1.0
2¼" D. H. sash to 4x7	1.25
Single inswinging casement	1.3
Double " "	2.0
Single outswinging casement	1.0
Double outswinging casement	1.4
3x7x1¾" wood door, spring bronze	1.6
3x7x2¼" wood door " "	2.0
3x7x1¾" wood door interlock	2.5
1 pr. 1¾" french doors	2.3

If weatherstripping is applied to windows in occupied space, add one-half hour per unit.

Reglazing

It is difficult to give guides for reglazing as job conditions will vary considerably. Some jobs will require salvage, some will require scaffolding, some, replacing stops. However, assuming none of these are required and the sash is prepared, on a job of moderate size the following labor costs may be used:

Labor Setting Window or Plate Glass In Wood Sash Using Glazing Compound

Glass Size	No. of Lites Per 8 Hr. Day	Glazier Hours Per 100 Lights	Lbs of Putty Per Lite
12x14	65	12.5	⅜ lb.
20x28	40	20	1-lb.
30x40	30	26.7	1½ lb.
40x48	20	40.0	2 lb.

Labor Glazing Steel Casements

Size	No. of Lites Per 8 Hr. Day	Glazier Hours Per 100 Lites	Lbs of Putty Per Lite
9x12	60	20	0.75
16x12	60	23	1.0
18x12	60	23	1.0

Approximate Cost of Sheet Glass Per Sq. Ft.

Type	Max. Size	Per Sq. Ft. Cost
S. S. 3/32"	40"x50"	$0.35
D. S. 1/8"	60"x80"	.44
3/16"	120"x84"	.60
7/32"	120"x84"	.72

Wood sash putty will cost about 12 cts per pound; steel sash putty, 15 cts; glazing compound 20 cts to 25 cts.

To add storm and screen doors and windows.—

Combination Screen and Storm Door

	Hours	Rate	Total	Rate	Total
Carpenter	1.3	$....	$....	$6.75	$ 8.78
Helper	1.3	....	....	5.00	6.50
Wood door 1-⅛" pine and hardware, 3x7, with alum. screening			$....	32.00	32.00
					$47.28

Wood Storm Windows

A carpenter with helper should set an average preglazed storm window in 1½ hours. Storm windows in wood, up to 12 sq. ft. in area, will average about $8.00 per unit. Larger units will take more time. Smaller units can be handled by a carpenter working alone.

Wood Screen Windows

A carpenter with helper should set a wood screen window in 1.3 hours. Screens with bronze or aluminum screening will average $4.00 for small windows, $6.50 for medium, and $9.00 for large openings.

To Replace Garage Doors

Single Door

	Hours	Rate	Total	Rate	Total
Carpenter	4	$....	$....	$ 6.75	$ 27.00
8′x8′ door with hardware				110.00	110.00
					$137.00

Double Door

	Hours	Rate	Total	Rate	Total
Carpenter	6	$....	$....	$ 6.75	$ 40.50
8′x17′ door with hardware				240.00	240.00
					$280.50

Porch Repairs

To replace an existing porch floor with new $\frac{25}{32}$″x3-¼″ face soft wood, allow 2 carpenter hours and 1 laborer hour per 100 sq. ft. Painting not included.

To replace a simple porch column, allow ½ hour to remove and shore existing column, 1 hour to replace column.

To replace a simple wood porch railing, figure a carpenter can remove and replace 15 lin. ft. per 8 hour day.

To erect an exterior utility stair of 2x10 stringers, allow 20 carpenter hours per average story in one run, 25 hours if stair has intermediate landing.

Roof Repairs

To Remove Built-Up Roofing.—To remove a 3 to 5 ply roof, figure ½ hour each of a roofer's and laborer's time per each square.

To Replace Built-up Roofing.—Figure a crew of 5 per 8 hour day can install 18 squares of 5 ply roofing, 22 squares of 4 ply and 24 squares of 3 ply roofing over wood decks on low buildings.

To Replace Shingle Roofing.—To remove asphalt roof shingles and underlayment, figure 1 roofer and 1 laborer working together can strip around 20 squares per 8 hour day. A carpenter can install a square of 12"x36" strip asphalt shingles on plain double pitch or gable roofs without hips, valleys or dormers in 2 hours, or at a cost of $24.00 per square for 235 lb., or very lightweight shingles, to $30.00 a square for 315 lb. or heavy shingles. New shingles are often applied over existing.

To replace sheet metal gutters, a tinner and a helper should replace 20 lin. ft. of gutter and 25 lin. ft. of downspout per hour.

To replace metal counterflashing, figure 1 tinner can replace 15 lin. ft. per hour providing a satisfactory raggle exists. If a raggle has to be chiseled into masonry, figure 1 laborer can cut 8 to 10 lin. ft. per hour. If an electric cutting saw can be used, figure 12 to 15 lin. ft. per hour.

Chimney Flashing Table

No. of Brick		Inches		Pitch of Roof		
Wide	Long	Wide	Long	To ⅓	To ½	To ¾
				Lin. Ft. of Flashing		
2	2	18"	18"	11'	11'	12'
2	2½	18"	22"	12'	12'	13'
2	3	18"	26"	13'	13'	15'
2	3½	18"	30"	13'	14'	16'
2	4	18"	34"	14'	15'	17'
2½	4	22"	34"	15'	16'	18'
2½	4½	22"	38"	16'	17'	20'
2½	5	22"	43"	16'	18'	22'
2½	5½	22"	47"	17'	19'	23'
2½	6	22"	51"	18'	20'	24'

Material Requirements to Add a Gabled Dormer

(Roofing, Siding, Painting and Interior Finishes Not Included)

Materials & Size		Width of Dormer 5′	6′	8′	10′	12′
Rafter Headers	2″x6″	2-10′	2-12′	2-16′	4-10′	4-12′
Rafter Plates	2″x6″	2-16′	2-16′	2-16′	2-16′	2-16′
Studs and Plates						
Side	2″x4″	2-10′	2-10′	2-10′	2-10′	2-10′
Side	2″x4″	2-12′	2-12′	2-12′	2-12′	2-12′
Front	2″x4″	7-10′	8-10′	11-10′	13-10′	11-12′
Gable	2″x4″	1-12′	1-12′	3-10′	2-10′	2-12′
Gable	2″x4″	1-8′	1-8′	1-10′	1-14′	1-14′
Rafters	2″x4″	6-8′	6-10′	6-12′	6-12′	6-14′
Ridge Boards	1″x6″	1-10′	1-10′	1-10′	1-10′	1-10′
Framing						
Total BM		179 BM	200 BM	237 BM	264 BM	283 BM
Sheathing	1″x6″	60 BM	70 BM	70 BM	85 BM	80 BM
Roof Boards	1″x6″	60 BM	72 BM	86 BM	100 BM	120 BM
Cornice Fascia	1″x6″	22 Lin. Ft.	24 Lin. Ft.	26 Lin. Ft.	28 Lin. Ft.	30 Lin. Ft.
Crown Mold	1″x3″	22 Lin. Ft.	24 Lin. Ft.	26 Lin. Ft.	28 Lin. Ft.	30 Lin. Ft.
Nails		10 lb.	11 lb.	12 lb.	13 lb.	14 lb.
Flashing	12″ Wide	33 Lin. Ft.	35 Lin. Ft.	39 Lin. Ft.	42 Lin. Ft.	46 Lin. Ft.
Felt	30 lb.	1 RL.	1 Rl.	1 Rl.	1 Rl.	2 Rl.
Window Frame	2/6x4/10	1	1	2	2	3
Window Sash	2/6x4/10	1	1	2	2	3
Labor To Install		26 Hours	27 Hrs.	32 Hrs.	36 Hrs.	40 Hrs.

Gabled Dormer Roof and Side Areas for ½ Pitch Roofs

	5′ Width	6′ Width	8′ Width	10′ Width	12′ Width
Roof	60 Sq. Ft.	72 Sq. Ft.	86 Sq. Ft.	100 Sq. Ft.	120 Sq. Ft.
Wall	60 Sq. Ft.	70 Sq. Ft.	70 Sq. Ft.	85 Sq. Ft.	80 Sq. Ft.
Starter	10 Lin. Ft.	10 Lin. Ft.	10 Lin. Ft.	10 Lin. Ft.	10 Lin. Ft.
Ridge	12 Lin. Ft.	12 Lin. Ft.	12 Lin. Ft.	12 Lin. Ft.	12 Lin. Ft.

INTERIOR WORK

Walls.—To strip a wall of plaster and leave ready to replaster, if masonry, or relath and plaster, figure 1 laborer will strip from 60 to 70 sq. ft. per hour. Add for cost of clean up and debris removal if this is to be included.

To replaster a stripped masonry unit partition with 2 coat gypsum cement plaster, figure as follows per 100 sq. yds.:

	Hours	Rate	Total	Rate	Total
1100 lbs. gypsum plaster		$....	$....	$1.50	$ 16.50
33 cu. ft. sand		....	....	.17	5.61
340 lbs. hydrated lime		....	....	2.40	8.16
170 lbs. gauging plaster		....	....	2.00	3.40
Plasterer	17	....	....	6.50	110.50
Laborer	10	....	....	5.00	50.00
Cost per 100 sq. yds.	27		$....		$194.17
Cost per sq. yd.					1.94

Three coat work will run around $2.00 a square yard. Work involving small areas with corner beads, etc., will run much more.

To add ⅜" gypsum lath and 2 coat gypsum cement plaster on stripped wood studs, figure as follows per 100 sq. yds.:

	Hours	Rate	Total	Rate	Total
900 sq. ft. ⅜" gypsum lath		$....	$....	$0.06	$ 54.00
7 lbs. nails		....	....	.25	1.75
Lather	8	....	....	6.50	52.00
1000 lbs. gypsum plaster		....	....	1.50	15.00
25 cu. ft. sand		....	....	.17	4.25
340 lbs. fin. hydrated lime		....	....	2.40	8.16
170 lbs. gauging plaster		....	....	2.00	3.40
Plasterer	16	....	....	6.50	104.00
Laborer	9	....	....	5.00	45.00
Cost per 100 sq. yds.	33		$....		$287.56
Cost per sq. yd.					2.88

Beads and moldings should be figured separately. If wired or stapled to lath, figure 2-½ hrs. per 100 lin. ft.; if nailed to masonry, figure 3 hours per 100 lin. ft. Where door and window casing beads are involved, figure 1 hour for each opening. Corner reinforcing at inside angles can be figured at 500 lin. ft. per 8 hour day.

To add ½" gypsum board over stripped wood studs, figure 1 carpenter will place around 50 sq. ft. per hour in the average room. If large unbroken expanses are involved, he may double this. If gypsum board is not a pre-finished type but is to be painted, it will require taping. Figure a carpenter will tape 100 lin. ft. of joint, which, in usual applications, would cover the needs of 300 sq. ft. of wall in about 4 hours.

When this pre-finished plywood is specified for first class work, gypsum back-up board should be used as an underlayment. Back-up board costs about ¾¢ less per sq. ft. than plasterboard of the same thickness. It is not taped.

To add wallboard over an existing wood stud and plaster wall, the wall should first be furred. Furring strips should be nailed at right angles to studs. Any convenient width may be used, but it must be wide enough to provide a nailing base to nail all edges of the decorative strips at least every 6". Furring may be of No. 2 soft wood. The success of the wall will depend largely on the success of leveling the furring strips.

With studs 16" on center, a carpenter should cut and place 300 to 350 lin. ft. of furring strips per 8 hour day at the following labor cost per 100 lin. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.5	$....	$....	$6.75	$16.88
Cost per lineal foot:					.17

When applying wallboard in smaller rooms requiring considerable cutting and fitting around doors, windows, etc., a carpenter should fit and place 275 to 300 sq. ft. per 8 hour day, at the following labor cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
Carpenter	2.7	$....	$....	$6.75	$18.23
Cost per sq. ft.					.18

In large rooms with unbroken walls, this cost would be reduced to about 13¢ per sq. ft.

To add thin board, such as 5/32" Masonite tempered Presdwood, which can be scored 4"x4" to represent tile over an existing plaster base with adhesive, figure as follows per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
105 sq. ft. tileboard		$....	$....	$0.50	$52.50
1.5 gal. adhesive		....	....	4.00	6.00
Carpenter	8	....	....	6.75	54.00
Cost per 100 sq. ft.	8		$....		$112.50
Cost per sq. ft.					1.13

To remove ceramic tile from an existing wall, figure one laborer will remove around 30 to 40 sq. ft. per hour, not including removal of debris. As old existing tile is undoubtedly set in a mortar base,

it will be necessary to set the new in the same way or to replaster the wall to provide a smooth base for applying tile with adhesive. 4"x4" tile applied with mortar will run about $2.25 per sq. ft. Adhesive set tile will run in the neighborhood of $1.50 to $1.75 per sq. ft. to which must be added to the cost of a new base.

Ceilings

To remove plaster from ceiling joists, figure 1 laborer will clear about 50 sq. ft. of area per hour. If the ceiling is suspended and the hangers are also to be removed, figure about 30 sq. ft. per hour.

To strip a plastered ceiling of acoustical tile, figure 1 laborer can clear 75 sq. ft. per hour. These figures do not include removal of debris.

To add new plaster to ceilings will run approximately the same as the above figures for walls, the extra labor in working on the ceiling being offset by the fact there are few if any openings in it.

Thus $\frac{3}{8}$" gypsum lath and 2 coat gypsum plaster would run around $2.60 per sq. yd. in fairly large areas.

Often a contractor is asked to patch plaster over concrete or old plastered ceilings. This can be accomplished with the use of a product such as Plaster-Weld* which is brushed, rolled or sprayed on, and in an hour or so, recoated with the desired plaster finish. Plaster-Weld will cost approximately 40¢ per sq. yd. to apply with spray equipment.

To add 12"x12" wood fiber tile to existing plaster ceiling, figure 2 mechanics working together on a scaffolding of horses and planks can lay 800 tiles per day at the following cost per 100 sq. ft.:

	Hours	Rate	Total	Rate	Total
105 sq. ft. acoustical tile		$....	$....	$0.42	$44.10
1.75 gal. adhesive		....	....	1.00	1.75
Mechanics	2	....	....	6.50	13.00
Cost per 100 sq. ft.	2		$....		$58.85
Cost per sq. ft.					.59

Flooring

To Sand Existing Wood Floors.—When resurfacing existing floors the amount will vary from 300 to 1,000 sq. ft. per 8 hour day, depending on condition of flooring.

*Larsen Products Corp.

Cost of operating machine 1 hour will run as follows:

	Hours	Rate	Total	Rate	Total
Machine Expense	1	$....	$....	$1.50	$1.50
Abrasive paper		....	....	1.25	1.25
Operator-finisher	1	....	....	6.75	6.75
Cost per hour			$....		$9.50
Cost per sq. ft. @ 300 sq. ft. per 8 hour day					.25
" " " " @ 500 " " " " " "					.15
" " " " @ 750 " " " " " "					.10
" " " " @ 1000 " " " " " "					.08

To Remove Wood Subflooring.—Where existing subfloors are badly worn and must be removed, figure 1 carpenter and 1 laborer can remove 100 sq. ft. per hour at the following cost:

	Hours	Rate	Total	Rate	Total
Carpenter	1	$....	$....	$6.75	$6.75
Laborer	1	....	....	5.00	5.00
Cost per 100 sq. ft.			$....		$11.75
Cost per sq. ft.					.12

To Replace Wood Subfloors.—In small cut-up areas, a carpenter should lay between 700 and 800 b.m. per 8 hour day of 1"x6"s or 1"x8"s at the following labor cost per 1000 ft.

	Hours	Rate	Total	Rate	Total
Carpenter	10.6	$....	$....	$6.75	$71.55
Labor	6.0	....	....	5.00	30.00
			$....		$101.55

To Add Plywood Over Existing Subfloors.—Labor for 100 sq. ft. of plywood added over existing subfloor would be as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	1.0	$....	$....	$6.75	$6.75
Labor	0.5	....	....	5.00	2.50
Cost per 100 sq. ft.			$....		$9.25
Cost per sq. ft.					.09

To Add Plywood As a Subfloor Over Existing Wood Joists.—If plywood is added as a subfloor over joists, 2x4 wood blocking will be required to provide nailing for the long edges. Labor costs per 100 sq. ft. can be figured as follows:

	Hours	Rate	Total	Rate	Total
arpenter	2.0	$....	$....	$6.75	$13.50
abor	.5	....	....	5.00	2.50
ost per 100 sq. ft.			$....		$16.00
ost per sq. ft.					.16

To Add New Finished Flooring.—Once an existing subfloor is it in good condition or replaced, or given a good underlayment, e following installed costs per sq. ft. may be used for various oor finishes:

1x1 Ceramic Tile, Adhesive Set	$1.50 - $1.75
Asphalt Tile	.30 - .45
Vinyl Asbestos $\frac{1}{16}$"	.33 - .45
Linoleum .090"	.37 - .52
Vinyl Sheet .065"	.50 - .70
Cork Tile	.70 - .85
Vinyl Tile .050"	.80 - 1.05
Vinyl Sheet .070"	.80 - 1.05
Rubber Tile $\frac{1}{8}$"	.80 - 1.10
Vinyl Sheet .090"	.85 - 1.35
Vinyl Tile $\frac{1}{8}$"	1.20 - 2.40
9x9x$\frac{5}{32}$" Wood Block	.65 - .90

Trim

To Remove Existing Wood Base.—A carpenter and helper orking together should remove a one-piece wood base at the te of 100 lin. ft. per hour.

	Hours	Rate	Total	Rate	Total
arpenter	1	$....	$....	$6.75	$6.75
aborer	1	....	....	5.00	5.00
ost per 100 lin. ft.			$....		$11.75
ost per lin. ft.					.12

To Replace Wood Base.—To place a single member base plus rpet strip, allow 40¢ per lin. ft.

Cost of a 3" pine base is 15¢ per ft.

To place a two member base plus carpet strip, allow 46¢ per . ft.

To add new interior trim, the following guide may be used to ver labor to set the following:

Wood picture molding	$0.25	per lin. ft.
Wood chair rail	.32	" " "
Wood cornices	1.20	" " "
Panel strips	.30	" " "

To Replace Window Sash and Trim.—A carpenter should fi and hang, complete with sash cord, chain and weights or counter balances, 10 to 12 single sash per 8 hour day, at the followin labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$....	$....	$6.75	$10.13
Cost per single sash					$5.07

A carpenter should fit and hang 10 to 13 casement sash pe 8 hour day at the following labor cost per pair:

	Hours	Rate	Total	Rate	Total
Carpenter	1.4	$....	$....	$6.75	$9.45
Cost per single sash					$4.73

A carpenter should set a one member window trim and cap at 1. hours per window at the following labor cost:

	Hours	Rate	Total	Rate	Total
Carpenter	1.5	$....	$....	$6.75	$10.13

To Replace Wood Doors and Trim.—A carpenter should set plain wood jamb for a 3x7′ wood door in one hour, and trim sam both sides in 1.5 hours. To hang the door will take another hou for a total cost as follows:

	Hours	Rate	Total	Rate	Total
Carpenter	3.5	$....	$....	$6.75	$23.63

A frame set for 3x7 opening will run about $8.00 in pine, $13.0 in birch.

If door unit is prefit and knocked down, a carpenter shoul assemble and install it in one hour.

To Set Factory Assembled and Finished Kitchen Cabinets.— When setting factory assembled and finished kitchen cabinet about 0.15 hours of carpenter time for each sq. ft. of cabinet fac area should be allowed.

To Fit and Place Closet Shelving.—A carpenter should fit ar place approximately 125 sq. ft. of closet shelving per 8 hour da at the following labor cost per 100 sq. ft.

	Hours	Rate	Total	Rate	Total
Carpenter	6.4	$....	$....	$6.75	$43.20
Cost per sq. ft.					.43

To Install Rod in Closet.—A carpenter should install abo 3 hanging rods per hour at the following labor cost per rod:

	Hours	Rate	Total	Rate	Total
Carpenter	0.33	$....	$....	$6.75	$2.23

To Set Medicine Cabinets.—A carpenter should set 10 to 12 face mounted cabinets per 8 hour day at the following labor cost per cabinet:

	Hours	Rate	Total	Rate	Total
Carpenter	.75	$....	$....	$6.75	$5.06

To Set Bathroom Accessories.—A carpenter should set 30 to 34 bathroom accessories per 8 hour day at the following labor cost per accessory:

	Hours	Rate	Total	Rate	Total
Carpenter	.25	$....	$....	$6.75	$1.69

To Set Finish Hardware

Type	Carpenter Hrs. Each
Rim Lock	.5
Mortised Lock	1.0
Cylinder Lock	.5
Front Entrance Cylinder Lock	2.0
Surface Door Closer	1.0
Concealed Closer	3.0
Sash Lifts and Lock	.5
Kickplates	1.0

To Set Cabinet Hardware

Type	Carpenter Hrs. Each
Surface Bolts	.05
Offset Bolts	.1
Catches	.1
Drawer Pulls	.06
Knobs	.05
Rim Catch	.1
Mortise Lock	.4

PAINTING

To repaint exterior wood siding and trim:

	No. Sq. Ft./Hr.	Hrs./100 Sq. Ft.	Sq. Ft./Gal.
First Coat	115-125	.85	500-550
Second Coat	125-135	.75	575-625

If existing surface is in poor condition, add:

	No. Sq. Ft./Hr.	Hrs./100 Sq. Ft.	Sq. Ft./Gal.
Burning Paint Off	30-40	2.75	
Prime Coat	100-110	.95	400-450

To add 2 coats to wood shingles:

	No. Sq. Ft./Hr.	Hrs./100 Sq. Ft.	Sq. Ft./Gal.
First Coat, Oil	115-125	.82	250-300
Second Coat, Oil	150-160	.65	375-425
First Coat, Stain	75-85	1.2	120-150
Second Coat, Stain	115-130	.82	200-225

To Prepare Interior Work

Type of Work	No. Sq. Ft. Per Hr.	Hrs. Per 100 Sq. Ft.	Sq. Ft. Per Gal.
Sanding & Puttying	190-200	0.5	
Washing Enamel	85-90	1.15	
Removing Varnish with Liquid Remover	30-35	3.00	150-180
Wash & Touch Up Varnish	165-175	.60	
Add 1 Coat Varnish	100-110	.95	575-600
Burn Off Interior Trim	20-25	4.00	
Burn Off Flat Surfaces	30-35	3.00	
Spackle Over Flat Surface	60-65	1.60	140-150
Filling Wood Floors, Wiping	170-180	.57	425-450
Taping, Spotting & Sanding Gypsum Wallboard	90-110	1.00	
Wash Off Calcimine	115-125	.83	
Wash Smooth Wall	145-155	.67	
Remove Old Wallpaper	65-75	1.45	
Wash Off Glue	125-135	.77	

To Paint Interior Work

Type of Work	No. Sq. Ft. Per Hr.	Hrs. Per 100 Sq. Ft.	Sq. Ft. Per Gal.
Wood Floors			
1st Coat Paint	290-300	0.35	525-550
2nd Coat Paint	260-270	0.38	425-450
1st Coat Stainwax	390-400	.25	525-550
2nd Coat Stainwax	480-490	.21	600-625
Varnish, Each Coat	300-310	.33	500-550
Buffing	390-400	.25	.....
Waxing	200-210	.50	1,050-1,075
Walls			
Sizing	350-400	.27	600-700
Sealer	200-225	.45	575-625

Flat Finish 1st Coat	165-175	.60	500-550
2nd Coat	175-185	.55	575-625
Latex 1st Coat	140-160	.67	300-350
2nd Coat	140-160	.67	300-350
Canvas	50-60	1.82	
Wallpaper			
Per Single Roll	2½-3		
Trim			
Enamel			
Undercoat	90-100	1.10	375-400
Finish Coat	100-110	1.00	475-500
Stain Woodwork	215-225	.45	700-725
Shellac Woodwork	215-225	.45	700-725
Varnish Woodwork	165-175	.60	425-450
Wax and Polish	100-110	.95	550-600

PLUMBING

The following may be used as a guide for replacing existing fixtures. No roughing in or pipe replacement is figured. Fixture cost and roughing in is discussed in Chapter XXIX.

	Hours
To Replace Bathtub	8
To Add Shower-Surface MTD	2
To Replace Single Kitchen Sink	5
To Replace Double Kitchen Sink	7
To Replace Laundry Tub	5
To Replace Lavatory	5
To Replace Shower Stall	12
To Replace Water Closet	7
To Replace Water Heater	4

ELECTRICAL

To rewire, pulling in old conduit:

Per outlet—2.5 hours.

To add new, using BX cable in open wall:

Per outlet—1 hour.

Budget figures for remodeling residential work using armored cable and including labor and materials but not fixtures or patching, unless so noted, would run somewhat as follows:

To add a ceiling outlet	$15.00
To add a wall switch	16.00
To add a wall outlet	17.00
Wire and connect a dishwasher	60.00
Wire and connect a clothes washer	65.00
Wire and connect a disposal	65.00

To furnish, wire and connect the following:

40 gal. electric water heater	$125.00
52 gal. electric water heater	165.00
82 gal. electric water heater	175.00

CHAPTER XXXII

CRITICAL PATH METHOD, PROGRESS REPORTS AND MENSURATION

The Critical Path Method (CPM) is a management tool which can provide contractors with more precise planning and scheduling techniques by graphically showing each activity in a project and its relationship to other activities. Critical Path provides an accurate picture of where the project stands, what remains to be done and which jobs are critical to finishing on time.

Critical Path Method encourages decisions but can not make them. The preparation of the diagram helps the planner to understand the project through the various activities involved in the project.

CPM is a logical and organized planning system. It is important that the physical layout of the network reflects this same logical organization. The drawing size should be reasonable, using multiple sheets if necessary. Significant chains of activities should be centered to form a network backbone.

There are basically three stages of the Critical Path Method: CPM controls planning, scheduling, and costing.

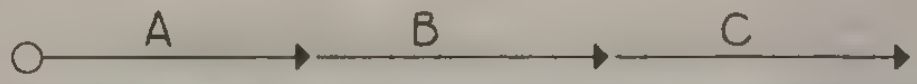
PLANNING—The first step is to separate activities of the project and place them in logical sequence. Some activities must precede others, some must follow others and others may be performed at the same time. After the sequence is determined an arrow diagram is made.

The backbone of CPM is a graphic model of a project. The basic component is the arrow. Each arrow represents one activity in the project. The tail of the arrow represents the starting point of the activity and the head, the completion. The arrow is not drawn to scale and does not necessarily have to be a straight line.

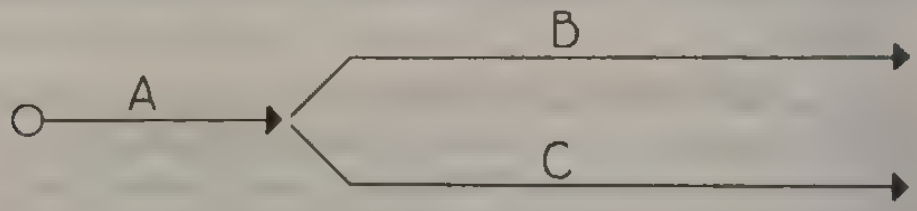
Arrows are arranged to show the plan or logical sequence in which the activities of the project are to be accomplished. The logical flow chart or diagram is the result of a network of

arrows indicating the decisions the planner makes to program the project.

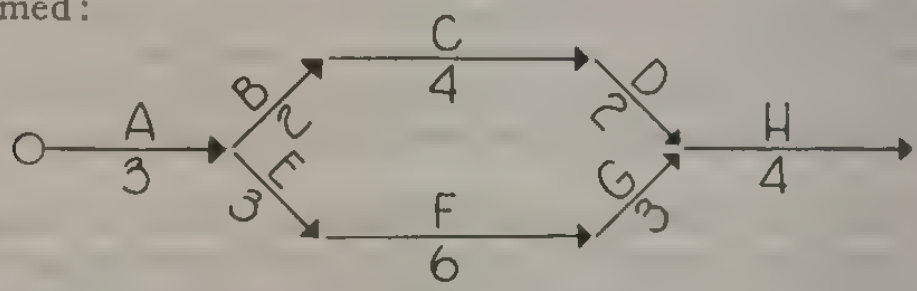
If a project will consist of three consecutive activities, the network will appear as follows:



If B and C are concurrent activities, the diagram would be:

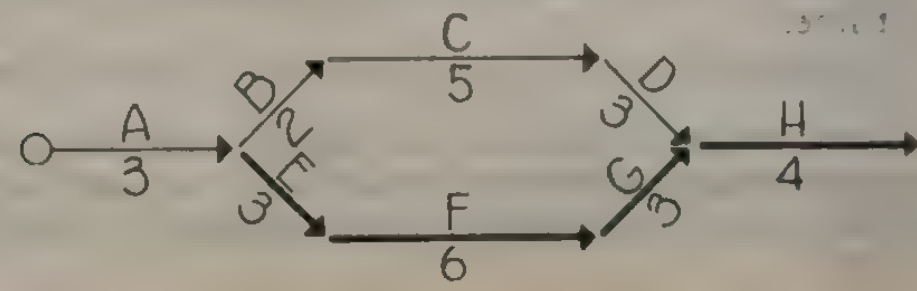


An activity D which follows activities B and C would be diagrammed:



A description of the activity should be written above each line represented above by letters A, B, C and D. At this point, the contractor is provided with a clear picture of sequence of activities to successfully complete the project.

SCHEDULING—Time estimates, usually referred to as activity duration, based on experience and knowledge, are determined for each activity and are shown below the arrow of the particular activity. Any convenient unit of time may be used, i.e., shifts, days or weeks, but it must be consistent throughout the network. The estimator assumes a normal work crew in estimating the duration of an activity. The Critical Path determines the length of the project. The longest path of activities through the network is the critical path as is shown below:



The project time to the two paths are summarized as follows:

Path I		*Path II*	
A	3 days	A	3 days
B	2 days	E	3 days
C	5 days	F	6 days
D	3 days	G	3 days
H	4 days	H	4 days
Total	17 days		19 days

Here it is noticed that Path II will take 19 days and therefore is the Critical Path. It is indicated by the heavy line in the diagram above and therefore is the latest completion date for the project. The activities B, C, D are not on the Critical Path and so are considered slack or float time.

It must be remembered that any change in the time for one of the activities on the Critical Path will result in an equal change in the over-all project time. Also, activities not on the Critical Path considered float time will have an Earliest Starting Time, Latest Starting Time, Earliest Finishing Time and Latest Finishing Time. Further, if an activity on the Critical Path is accelerated, an activity not on the original Critical Path may necessarily be moved to it.

With the time estimates completed, the contractor now has a clear, concise picture of the overall project. The network will show which activities are critical for the completion of the project on time.

DETERMINING COSTS

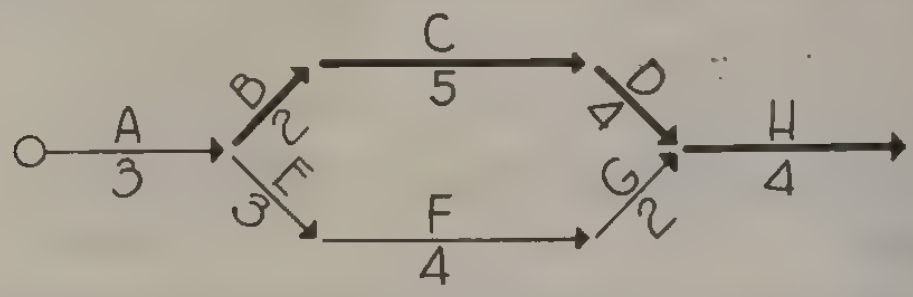
Critical Path is a tool that may be used to evaluate costs and provides a systematic way to determine the most profitable duration for a project. The optimum time schedule lies somewhere between the "normal" time for the project and the "crash time."

A CPM diagram computed on a normal time basis—that is, without extra direct costs such as overtime labor, is the starting point for preparation of a series of diagrams showing alternate methods of speeding the total project. The final, shortest schedule is the "Crash" schedule.

As activities on the project are shortened due to the crash program, the Critical Path may thereby shift, as the Critical Path is the longest path.

Referring to the diagram used previously, Path I and Path II were computed and Path II (A, E, F, G, H) was shown as the

Critical Path. After revision to a crash program, the following network was developed:



To effect a crash program the following schedule is proposed, Path III.

Path III		*Path I*	
A	3 days	A	3 days
E	2 days	B	3 days
F	4 days	C	2 days
G	2 days	D	4 days
H	4 days	H	4 days
Total	15 days		16 days

As a result of this crash program the Critical Path is now Path I.

Ordinarily, as time is cut from the normal schedule, direct costs increase; thus, as the series of schedules are prepared, direct costs will be at a minimum for the normal schedule and at a maximum for the crash schedule.

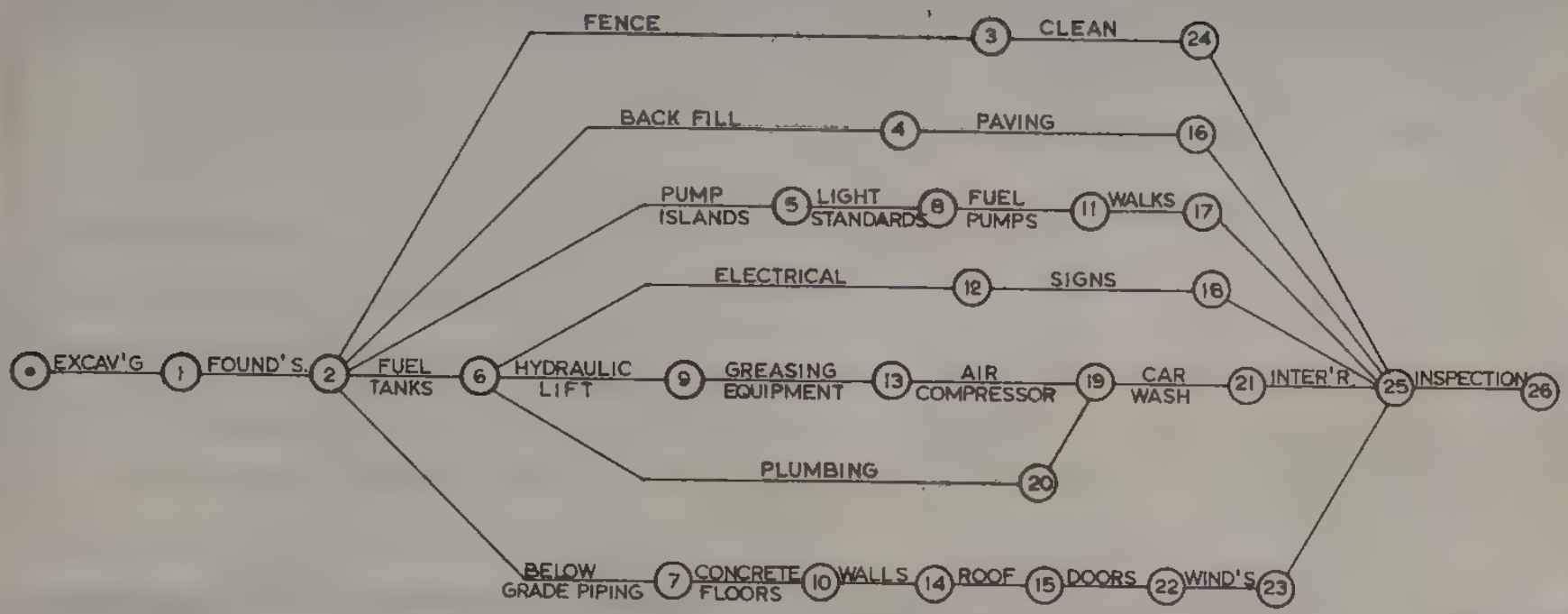
Indirect costs ordinarily will reduce as the project time is shortened.

CPM can show contractors just how much they can shorten the project time before reaching the point of diminishing returns as extra speed-up measures are sometimes more costly than they are worth.

The first step is to determine direct costs for the normal time Critical Path program. Next, the direct cost for the crash program is computed including overtime, extra equipment and other costs that may be required to effect the crash program. Between the crash program and the normal schedule lie a number of possible programs. A series of CPM diagrams for the various combinations of time and cost should be prepared.

If we chart the findings of the various diagrams broken down into direct costs, indirect costs and total costs, the optimum CPM program can be determined.

CPM FOR SERVICE STATION



DATES:

ESTIMATE AND COST SUMMARY

PROJECT: Store Building
LOCATION: 1292 Main
ARCH'T OR ENG'R: Andrews & Smith
CLASSIFICATION: General

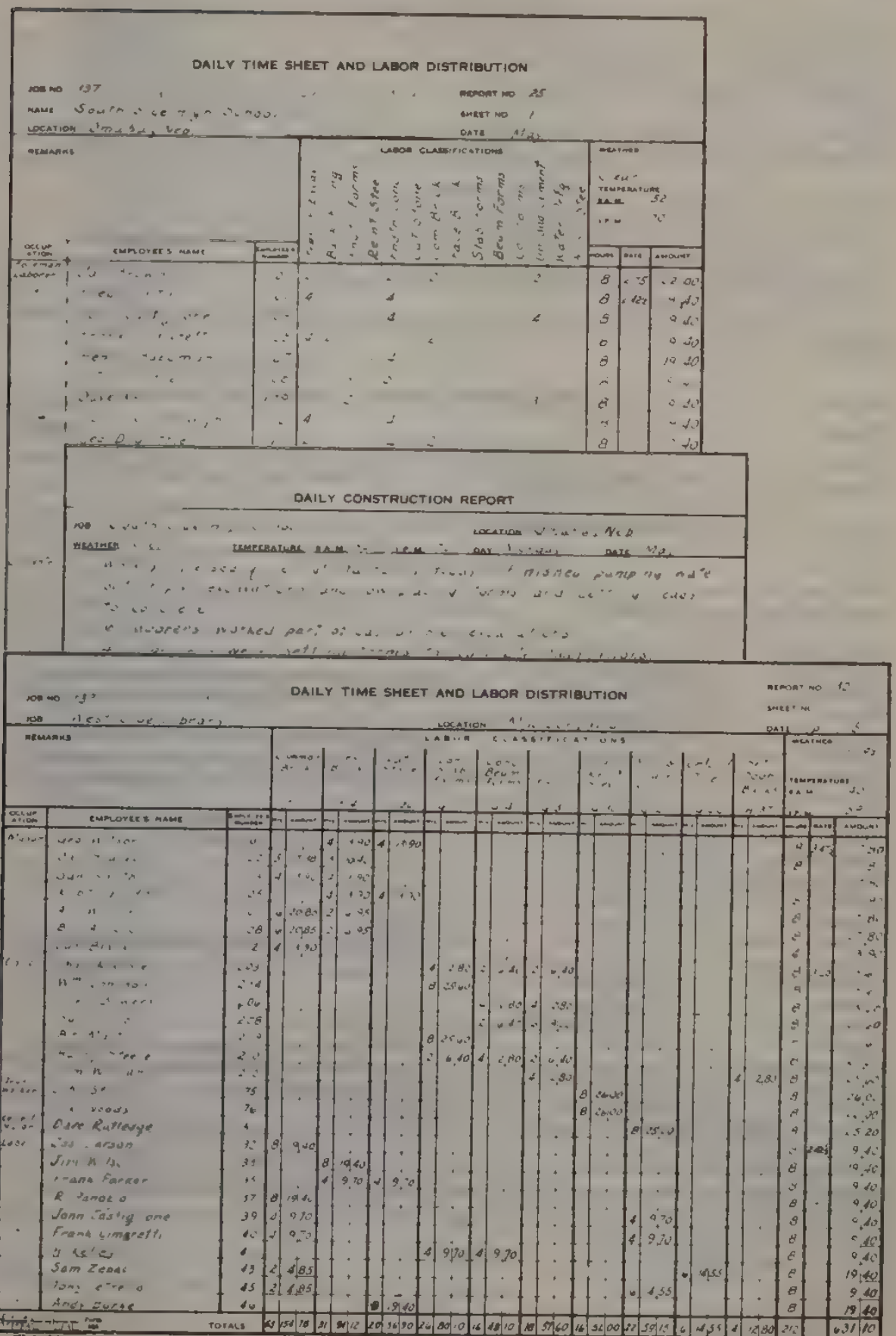
ESTIMATOR: F W
EXTENSIONS: J V L
CHECKED: O. L. T

ESTIMATE NO: 429
SHEET NO: 2 of 5
DATE: Nov 4, 19-

CODE	DESCRIPTION	ESTIMATED COST: MATERIAL UNIT	MATERIAL QUANTITY	MATERIAL UNIT COST	MATERIAL AMOUNT	LABOR HOURS	LABOR AMOUNT	SUB CONTRACTS	TOTAL ESTIMATE	% COMPLETED	ACTUAL COST: MATERIAL QUANTITY USED	MATERIAL UNIT COST	MATERIAL AMOUNT	LABOR HOURS	LABOR AMOUNT	SUB CONTRACTS	TOTAL COST	PROFIT OR LOSS
321	Excavation	CY	371	127	972 00			972 00	972 00	100	320	127	406 00				406 00	566 00
22	Grading					5	150 00	450 00	450 00	100				5	75 00		75 00	(300 00)
C-1-B	Concrete Foundations				94 80	44	210 00		302 00	100			52 00	60	204 00		256 00	46 00
C-1-B	Placing Concrete	CY	90	1190	4786 00	400	1640 00		2116 00	75	32	1190	619 00	418	1713 80		2332 80	(216 80)
	TOTALS																	

COMMENTS

Form 550



DAILY TIME SHEET AND LABOR DISTRIBUTION

JOB NO 137 REPORT NO 25

NAME South ... Bridge SHEET NO 1

LOCATION Omaha, Neb. DATE Aug.

REMARKS

LABOR CLASSIFICATIONS

WEATHER Clear TEMPERATURE A.M. 52 P.M. 70

OCCUPATION	EMPLOYEE'S NAME	EMPLOYEE'S NUMBER	Carp. Foreman	Asst. Carp. Foreman	Carpenters	Carp. Apprentice	Carp. Helper	Steel Erectors	Steel Foreman	Concrete Finishers	Concrete Laborers	Hoisting Engineer	Water Boy	HOURS	RATE	AMOUNT
Foreman Laborer	[illegible]	[illegible]										1		8	2.75	22.00
"	[illegible]	[illegible]			4			4						8	4.42½	44.00
"	[illegible]	[illegible]						3				4		8		92.00
"	[illegible]	[illegible]												8		80.00
"	[illegible]	[illegible]						2						8		19.40
"	[illegible]	[illegible]														
"	[illegible]	[illegible]										1		8		80.00
"	[illegible]	[illegible]	4					4						8		44.00
"	[illegible]	[illegible]												8		80.00

DAILY CONSTRUCTION REPORT

JOB [illegible] LOCATION [illegible], Neb.

WEATHER [illegible] TEMPERATURE A.M. [illegible] P.M. [illegible] DAY [illegible] DATE Aug.

[illegible] finished pumping out [illegible]

[illegible] workers worked part of [illegible]

DAILY TIME SHEET AND LABOR DISTRIBUTION

JOB NO [illegible] REPORT NO 12

JOB [illegible] SHEET NO

LOCATION [illegible] DATE

REMARKS

LABOR CLASSIFICATIONS

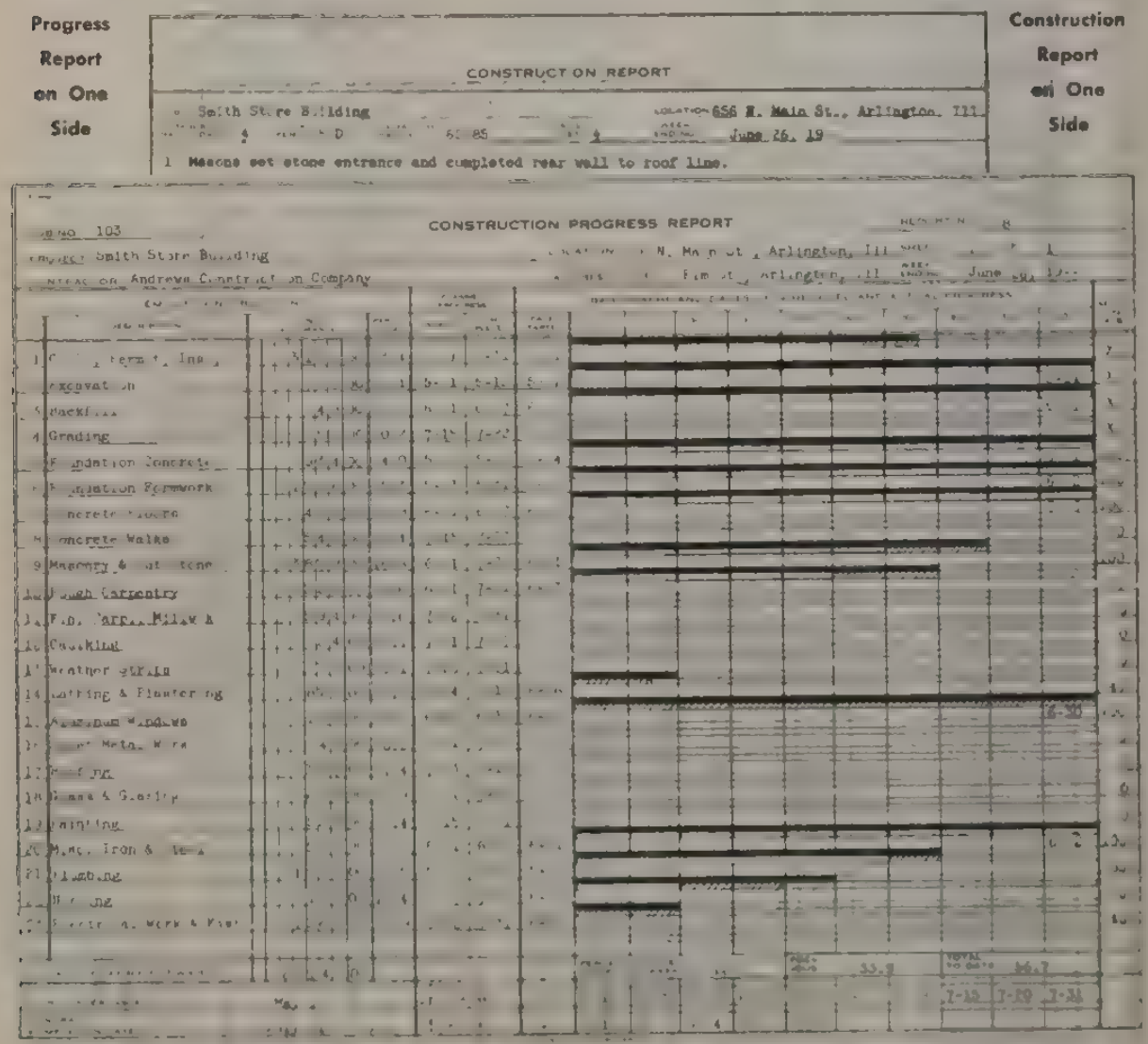
WEATHER

| OCCUPATION | EMPLOYEE'S NAME | EMPLOYEE'S NUMBER | [illegible] | [illegible] | [illegible]

The estimated costs and actual costs can be accumulated on Walker Practical Form 550, see page 1638. After estimates have been prepared employing the methods and forms described in Chapter III, the final accepted cost estimates are entered on Form 550. As costs are incurred entries are made on the form opposite the estimates for the respective activities. Comparisons will show the gains or losses for each activity and for the total project.

Labor costs can be accumulated on Walker Practical Form 505 Daily Time Sheet and Labor Distribution.

On large projects activities may be numbered or coded. Critical Path Method for large projects is easily adapted for use on computers.



Glossary of Critical Path Method terms:

Activity—a work item which is a component of the project.

Activity times—Identity of start and finish times for each activity in the network.

Arrow—Graphic representation of a single activity in the CPM network.

Critical Path—Specific sequence of activities in network which sets the maximum time for completion of a project.

Event—Point in time that marks the start of finish of an activity.

Network—The connected sequence of arrows representing the entire project.

Project—The overall work being planned.

Bibliography and suggested additional reading:

Network Analysis for Planning and Scheduling
Albert Batters—Saint Martin's Press

Operating Planning and Control
Arch R. Dooley

An introduction to Critical Path Analysis
K. G. Lockyer—Pitman Publishing Corporation

CPM in Construction Management
James Jerome O'Brien—McGraw-Hill

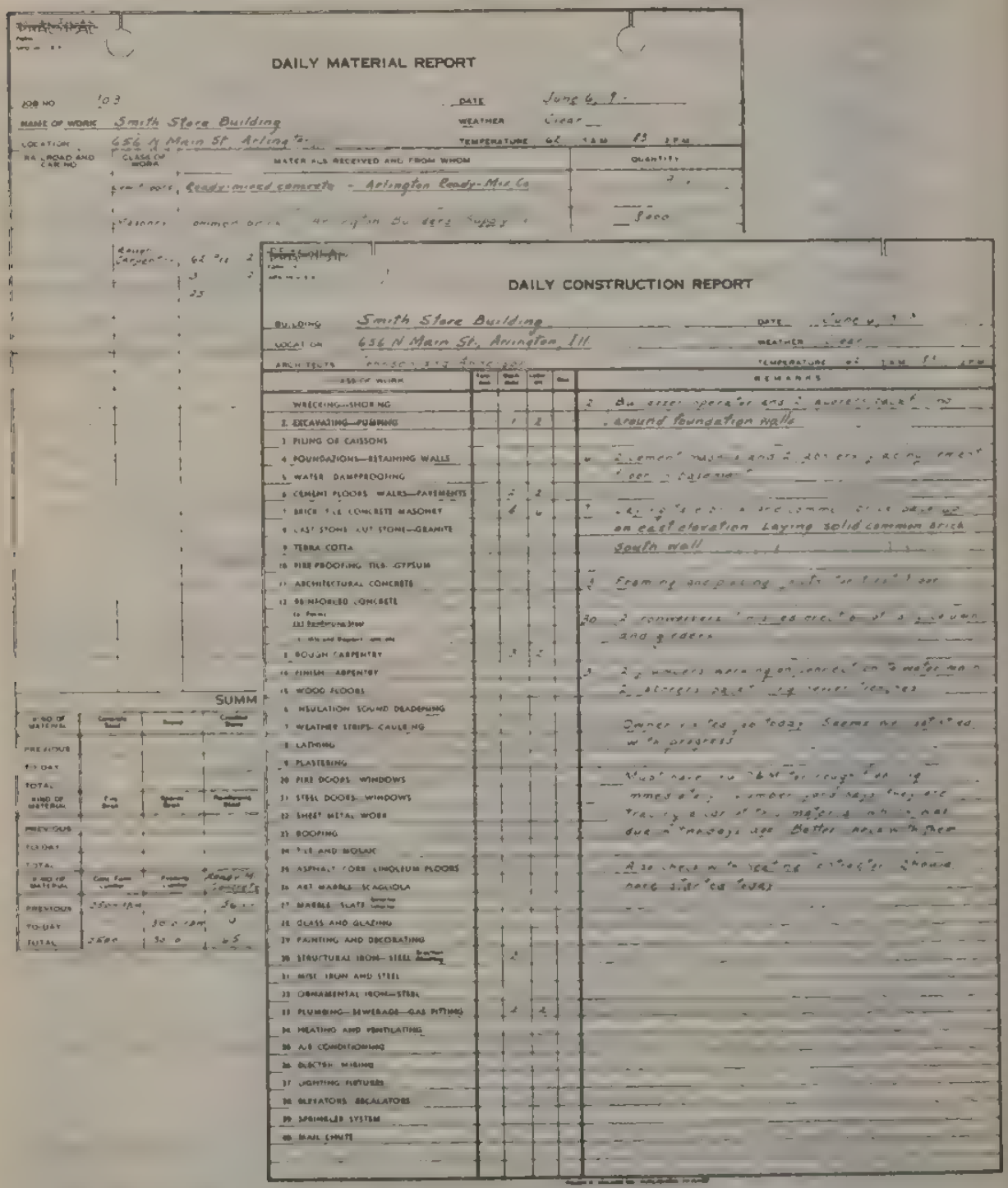
The Critical Path Method
L. R. Shaffer, J. B. Ritter and W. L. Meyer—McGraw-Hill

Modern Management Methods
David M. Stires—Boston Materials Management Institute

PROGRESS REPORTS

The Walker Practical Form 112 bar graph is a graphic representation of activity. It is easily read and understood by all levels of management and supervision. At times CPM information is transferred to a bar graph.

Daily record of the progress of a project can be reported on Walker Practical Form 110-111. Information showing the number of men working, materials received and used are reported on the form as well as other pertinent data.



DAILY MATERIAL REPORT

JOB NO 103 DATE June 6 19..

NAME OF WORK Smith Store Building WEATHER Clear

LOCATION 656 N Main St Arlington TEMPERATURE 62 AM 83 PM

R.R. LOAD AND CAR NO.	CLASS OF WORK	MATER IALS RECEIVED AND FROM WHOM	QUANTITY
		Ready-mixed concrete - Arlington Ready-Mix Co	3 Yds
		common brick - Arlington Building Supply	5000

DAILY CONSTRUCTION REPORT

BUILDING Smith Store Building DATE June 6 19..

LOCATION 656 N Main St, Arlington, Ill WEATHER clear

ARCHITECTS Conrad & Smith Akron, Ohio TEMPERATURE 62° 7 AM 83° 1 PM

KIND OF WORK	Hours men	Hours mach	Labor cost	Cost	REMARKS
WRECKING—SHORING					2 Bu steel operator and 2 laborers install [illegible]
2 EXCAVATING—PUMPING		1	2		around foundation walls
3 PILING OR CAISSONS					
4 FOUNDATIONS—RETAINING WALLS					4 cement mason and 2 laborers placing cement floor & [illegible]
5 WATER DAMPPROOFING					
6 CEMENT FLOORS WALKS—PAVEMENTS		2	2		
7 BRICK TILE CONCRETE MASONRY		4	4		4 bricklayers and 4 common laborers working on east elevation Laying solid common brick
8 CUT STONE—GRANITE					South wall
9 TERRA COTTA					
10 FIRE PROOFING TILE GYPSUM					
11 ARCHITECTURAL CONCRETE					4 Foreman placing forms for floor and
12 REINFORCED CONCRETE (a) Floors (b) Reinforcing Steel					20 2 carpenters [illegible] and 2 laborers and 2 floors
13 ROUGH CARPENTRY		3	2		
14 FINISH ASPENTRY					3 2 workers working on concrete on 2 main and 2 laborers placing concrete floors
15 WOOD FLOORS					
16 INSULATION SOUND DEADENING					
17 WEATHER STRIPS—CAULKING					Owner is [illegible] Seems not satisfied with progress
18 LATHING					
19 PLASTERING					
20 FIRE DOORS WINDOWS					Work here on [illegible] of rough floor [illegible]
21 STEEL DOORS WINDOWS					times also [illegible] lumber yard says they are
22 SHEET METAL WORK					trying to get all of the material on hand
23 ROOFING					due [illegible] Masons say Better not work on floor
24 TILE AND MOSAIC					
25 ASPHALT CORK LINOLEUM FLOORS					Also check on [illegible] of [illegible] Ground
26 ART MARBLE SCAGLIOLA					here [illegible] [illegible] levels
27 MARBLE SLATE					
28 GLASS AND GLAZING					
29 PAINTING AND DECORATING					
30 STRUCTURAL IRON—STEEL		2			
31 MISC IRON AND STEEL					
32 ORNAMENTAL IRON—STEEL					
33 PLUMBING—SEWERAGE—GAS FITTING		2	2		
34 HEATING AND VENTILATING					
35 AIR CONDITIONING					
36 ELECTRIC WIRING					
37 LIGHTING FIXTURES					
38 ELEVATORS ESCALATORS					
39 SPRINKLER SYSTEM					
40 MAIL CHUTE					

SUMM

NO OF MATERIAL	Concrete Steel	Steel	Concrete Stone
PREVIOUS			
TO DAY			
TOTAL			
KIND OF MATERIAL	Conc Steel	Steel	Ready Mixed Concrete
PREVIOUS	[illegible]		56 [illegible]
TO-DAY		30 [illegible]	0
TOTAL	2500	30 0	[illegible]

Daily Construction and Material Report, Form 110-111

MENSURATION

The information on the following pages will enable contractors and estimators to estimate quantities and costs accurately and in a minimum of time.

In a number of tables, the quantities are stated in decimals, as by using decimals, it is possible to state the fractional parts of inches, feet and yards, in a smaller space than where regular fractions are used.

For the contractor or estimator who is not thoroughly familiar with the decimal system, complete explanations are given covering the use of all classes of decimal fractions, so they may be used rapidly and accurately.

Estimating is nearly all "figures" of one kind or another, so it is essential that the contractor and estimator possess a fair working knowledge of arithmetic, if his estimates are to be accurate and dependable.

Most of the estimator's computations involve measurements of surface and cubical contents and are stated in lineal feet (lin.ft.), square feet (sq.ft.), square yards (sq.yds.), squares (sqs.) containing 100 sq. ft., cubic feet (cu.ft.), and cubic yards (cu.yds.). These quantities are often further reduced to thousands of brick, feet of lumber, board measure (b.m.), etc.

The rules on the following pages will enable the user to compute areas in square feet or cubical contents easily, accurately and quickly.

The following abbreviations are used throughout the book to make all tables brief and concise and to insert them in the smallest possible space:

	Abbreviation	Symbols
Inches	= in.	= ″
Lineal feet	= lin. ft.	= ′
Feet and inches	= ft. in.	= 2′-5″
Square feet	= sq. ft.	= □′
Square yards	= sq. yds.	= □ yds.
Squares	= sqs.	
Cubic feet	= cu. ft.	
Cubic yards	= cu. yds.	
Board measure	= b. m.	

Linear Measure

12	inches	=12	in.= 12″	=1 foot	=1 ft.	=1′-0″
3	feet	= 3	ft.= 3′- 0″	=1 yard	=1 yd.	
16½	feet	=16½	ft.=16′- 6″	=1 rod	=1 rd.	
40	rods	=40	rds.	=1 furlong	=1 fur.	
8	furlongs	= 8	fur.	=1 mile	=1 mi.	
5,280	feet	=1,760	yds.	=1 mile	=1 mi.	

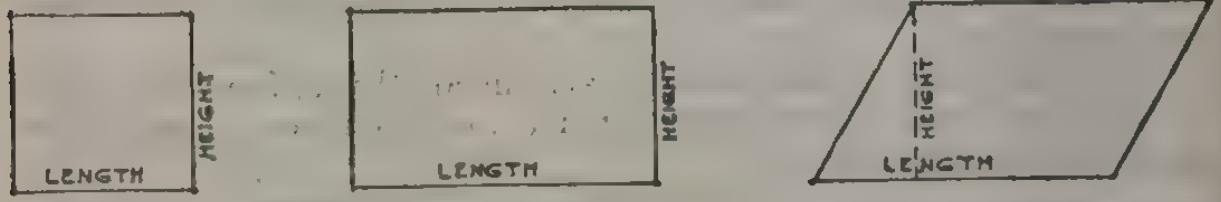
Square Measure or Measures of Surfaces

144 square inches = 144 sq. in. = 1 square foot = 1 sq. ft.
9 square feet = 9 sq. ft. = 1 square yard = 1 sq. yd.
100 square feet = 100 sq. ft. = 1 square = 1 sq. (Architects' and Builders' Measure.)
30¼ square yards = 30¼ sq. yds. = 30.25 sq. yds. = 1 square rod = 1 sq. rd.
160 square rods = 160 sq. rds. = 1 Acre = 1 A.
43,560 sq. ft. = 4,840 sq. yds. = 1 Acre = 1 A.
640 acres = 640 A. = 1 square mile = 1 sq. mi.

Cubic Measure or Cubical Contents

1,728 cubic inches = 1,728 cu. in. = 1 cubic foot = 1 cu. ft.
27 cubic feet = 27 cu. ft. = 1 cubic yard = 1 cu. yd.
128 cubic feet = 128 cu. ft. = 1 cord = 1 cd.
24¾ cubic feet = 24¾ cu. ft. = 24.75 cu. ft. = 1 perch = 1P. * See Note

*A perch of stone is nominally 16½ ft. long, 1 ft. high and 1½ ft. thick, and contains 24¾ cu. ft. However, in some states, especially west of the Mississippi, rubble work is figured by the perch containing 16½ cu. ft. Before submitting prices on masonry by the perch, find out the common practice in your locality.



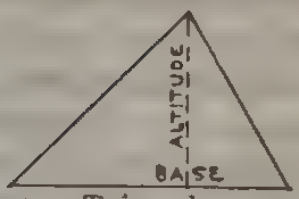
SQUARE RECTANGLE PARALLELOGRAM

To Compute the Area of a Square, Rectangle or Parallelogram.—Multiply the length by the breadth or height. Example: Obtain the area of a wall 22 ft. (22'-0") long and 9 ft. (9'-0") high. 22x9=198 sq. ft.

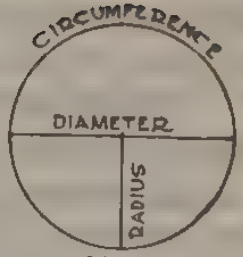
To Compute the Area of a Triangle.—Multiply the base by ½ the altitude or perpendicular height. Example: Find the area of the end gable of a house 24 ft. (24'-0") wide and 12 ft. (12'-0") high from the base to high point of roof. 24 ft. x 6 ft. (½ the height) = 144 sq. ft.

To Compute the Circumference of a Circle.—Multiply the diameter by 3.1416. The diameter multiplied by 3⅐ is close enough for all practical purposes. Example: Find the circumference or distance around a circle, the diameter of which is 12 ft. (12'-0"). 12x3.1416=37.6992 ft. the distance around the circle or 12x3⅐=37 or 37.714 ft.

Triangle



Triangle

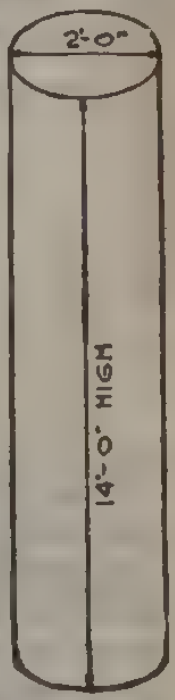


Circle

To Compute the Area of a Circle.—Multiply the square of the diameter by 0.7854 or multiply the square of the radius by 3.1416. Example: Find the area of a round concrete column 24 in. (24″ or 2′-0″) in diameter. The square of the diameter is 2x2=4. 4x0.7854=3.1416 sq. ft. the area of the circle.

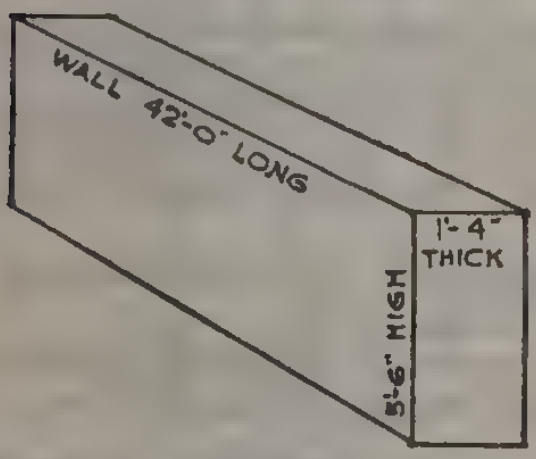
The radius is ½ the diameter. If the diameter is 2 ft. (2′-0″) the radius would be 1 ft. (1′-0″). To obtain the square of the radius, 1x1=1. Multiply the square of the radius, 1x3.1416= 3.1416, the area of the circle.

To Compute the Cubical Contents of a Circular Column.—Multiply the area of the circle by the height. Example: Find the cubical contents of a round concrete column 2 ft. (2′-0″) in diameter and 14 ft. (14′-0″) long.



From the previous example, the area of a circle 2 ft. in diameter is 3.1416 sq. ft. 3.1416x14 ft. (the height),=43.9824 cu. ft. or for all practical purposes 44 cu. ft. of concrete in each column.

To Compute the Cubical Contents of any Solid.—



Multiply the length by the breadth or height by the thickness. Computations of this kind are used extensively in estimating all classes of building work, such as excavating, concrete foundations, reinforced concrete, brick masonry, cut stone, granite, etc.

Example: Find the cubical contents of a wall 42 ft. (42′-0″) long, 5 ft. 6 in. (5′-6″) high, and 1 ft. 4 in. (1′-4″) thick. 42′-0″x 5′-6″x1′-4″=308 cu. ft. To reduce cu. ft. to cu. yds. divide 308 by 27, and the result is $11\frac{1}{27}$ or $11\frac{1}{3}$ or 11.41 cu. yds.

How to Use the Decimal System of Numerals in Estimating.—In construction work nearly all figures are either feet and

inches or dollars and cents but inasmuch as it is convenient to use the decimal system in making many computations, a brief description of this system is given for the use of contractors and estimators who are not familiar with it.

A decimal is a fraction whose denominator is not written, but is some power of 10. They are often called decimal fractions but more often simply a decimal.

Example: We know 50 cents is $\frac{50}{100}$ or $\frac{1}{2}$ of a dollar. Writing the same thing in decimals would be \$0.50.

Numerator	50
Denominator	100

When written as .50 or .5, it is a fraction whose denominator is not written, it being understood to be 10 from the fact that 5 occupies the first place to the right of the decimal point.

Therefore we have the following:

0.5 means $\frac{5}{10}$, for the 5 extends to the 10th's place;
0.25 means $\frac{25}{100}$, for the 25 extends to the 100dth's place;
0.125 means $\frac{125}{1000}$, for the 125 extends to the 1000dth's place.

The names of the places are, in part, as follows:

Thousands	Hundreds	Tens	Units	(Decimal Point)	Tenths	Hundredths	Thousandths	Ten-Thousandths
1	3	4	5	.	2	7	6	5

This number is read "one thousand three hundred forty-five and two thousand seven hundred and sixty-five ten thousandths." The orders beyond the ten thousandths are hundred thousandths, millionths, ten millionths, etc., but in figuring construction work it is seldom necessary to carry the figures beyond three or four decimal points.

A whole number and a decimal together, form a mixed decimal. Example: 2.25 is the same as $2\frac{25}{100}$ or $2\frac{1}{4}$.

The period written at the left of tenths is called the decimal point. Example. $0.5 = \frac{5}{10}$; $0.25 = \frac{25}{100} = \frac{1}{4}$; $0.375 = \frac{375}{1000} = \frac{3}{8}$, etc.

It is not necessary to write a zero at the left of the decimal point in the above examples, for 0.5 means the same as .5. The zero is often written there to call attention more quickly to the decimal point.

In the construction business, decimals are used chiefly to denote feet and inches, hours and minutes, the fractional work-

ing units of the various kinds of materials, and in money, which is dollars and cents or fractional parts of 100.

Table of Feet and Inches Reduced to Decimals

The following table illustrates how feet and inches may be expressed in four different ways, all meaning the same thing.

1 inch	= 1 ″ = $\frac{1}{12}$th	foot = 0.083
1$\frac{1}{2}$ inches	= 1$\frac{1}{2}$ ″ = $\frac{1}{8}$th	foot = 0.125
2 inches	= 2 ″ = $\frac{1}{6}$th	foot = 0.1667
2$\frac{1}{2}$ inches	= 2$\frac{1}{2}$ ″ = $\frac{5}{24}$ths	foot = 0.2087
3 inches	= 3 ″ = $\frac{1}{4}$th	foot = 0.25
3$\frac{1}{2}$ inches	= 3$\frac{1}{2}$ ″ = $\frac{7}{24}$ths	foot = 0.2917
4 inches	= 4 ″ = $\frac{1}{3}$rd	foot = 0.333
4$\frac{1}{2}$ inches	= 4$\frac{1}{2}$ ″ = $\frac{3}{8}$ths	foot = 0.375
5 inches	= 5 ″ = $\frac{5}{12}$ths	foot = 0.417
5$\frac{1}{2}$ inches	= 5$\frac{1}{2}$ ″ = $\frac{11}{24}$ths	foot = 0.458
6 inches	= 6 ″ = $\frac{1}{2}$	foot = 0.5
6$\frac{1}{2}$ inches	= 6$\frac{1}{2}$ ″ = $\frac{13}{24}$ths	foot = 0.5417
7 inches	= 7 ″ = $\frac{7}{12}$ths	foot = 0.583
7$\frac{1}{2}$ inches	= 7$\frac{1}{2}$ ″ = $\frac{5}{8}$ths	foot = 0.625
8 inches	= 8 ″ = $\frac{2}{3}$rds	foot = 0.667
8$\frac{1}{2}$ inches	= 8$\frac{1}{2}$ ″ = $\frac{17}{24}$ths	foot = 0.708
9 inches	= 9 ″ = $\frac{3}{4}$ths	foot = 0.75
9$\frac{1}{2}$ inches	= 9$\frac{1}{2}$ ″ = $\frac{19}{24}$ths	foot = 0.792
10 inches	= 10 ″ = $\frac{5}{6}$ths	foot = 0.833
10$\frac{1}{2}$ inches	= 10$\frac{1}{2}$ ″ = $\frac{7}{8}$ths	foot = 0.875
11 inches	= 11 ″ = $\frac{11}{12}$ths	foot = 0.917
11$\frac{1}{2}$ inches	= 11$\frac{1}{2}$ ″ = $\frac{23}{24}$ths	foot = 0.958
12 inches	= 12 ″ = 1	foot = 1.0

Example: Write 5 feet, 7$\frac{1}{2}$ inches, in decimals. It would be written 5.625, which is equivalent to 5$\frac{5}{8}$ feet.

Table of Common Fractions Stated in Decimals

The following table gives the decimal equivalents of common fractions frequently used in estimating:

$\frac{1}{16} = \frac{6\frac{1}{4}}{100} = 0.0625$	$\frac{7}{16} = \frac{43\frac{3}{4}}{100} = 0.4375$
$\frac{1}{8} = \frac{12\frac{1}{2}}{100} = 0.125$	$\frac{1}{2} = \frac{50}{100} = 0.5$
$\frac{3}{16} = \frac{18\frac{3}{4}}{100} = 0.1875$	$\frac{9}{16} = \frac{56\frac{1}{4}}{100} = 0.5625$
$\frac{1}{4} = \frac{25}{100} = 0.25$	$\frac{5}{8} = \frac{62\frac{1}{2}}{100} = 0.625$
$\frac{5}{16} = \frac{31\frac{1}{4}}{100} = 0.3125$	$\frac{11}{16} = \frac{68\frac{3}{4}}{100} = 0.6875$
$\frac{3}{8} = \frac{37\frac{1}{2}}{100} = 0.375$	$\frac{3}{4} = \frac{75}{100} = 0.75$

Table of Common Fractions Stated in Decimals—Cont'd.

$\frac{13}{16} = \frac{81\frac{1}{4}}{100} = 0.8125$ $\qquad$ $\frac{15}{16} = \frac{93\frac{3}{4}}{100} = 0.9375$

$\frac{7}{8} = \frac{87\frac{1}{2}}{100} = 0.875$ $\qquad$ $\frac{8}{8} = \frac{100}{100} = 1.0$

Annexing zeros to a number does not change its value; 0.5 is the same as 0.500.

Table of Hours and Minutes Reduced to Decimals

The following table illustrates how minutes may be reduced to fractional parts of hours and to decimal parts of hours.

Number of Minutes	Fractional Part of an Hour	Decimal Part of an Hour	Number of Minutes	Fractional Part of an Hour	Decimal Part of an Hour
1	$\frac{1}{60}$th	0.0167	31	$\frac{31}{60}$ths	0.5167
2	$\frac{1}{30}$th	0.0333	32	$\frac{8}{15}$ths	0.5333
3	$\frac{1}{20}$th	0.05	33	$\frac{11}{20}$ths	0.55
4	$\frac{1}{15}$th	0.0667	34	$\frac{17}{30}$ths	0.5667
5	$\frac{1}{12}$th	0.0833	35	$\frac{7}{12}$ths	0.5833
6	$\frac{1}{10}$th	0.10	36	$\frac{3}{5}$ths	0.60
7	$\frac{7}{60}$ths	0.1167	37	$\frac{37}{60}$ths	0.6167
8	$\frac{2}{15}$ths	0.1333	38	$\frac{19}{30}$ths	0.6333
9	$\frac{3}{20}$ths	0.15	39	$\frac{13}{20}$ths	0.65
10	$\frac{1}{6}$th	0.1667	40	$\frac{2}{3}$rds	0.6667
11	$\frac{11}{60}$ths	0.1833	41	$\frac{41}{60}$ths	0.6833
12	$\frac{1}{5}$th	0.20	42	$\frac{7}{10}$ths	0.70
13	$\frac{13}{60}$ths	0.2167	43	$\frac{43}{60}$ths	0.7167
14	$\frac{7}{30}$ths	0.2333	44	$\frac{11}{15}$ths	0.7333
15	$\frac{1}{4}$th	0.25	45	$\frac{3}{4}$ths	0.75
16	$\frac{4}{15}$ths	0.2667	46	$\frac{23}{30}$ths	0.7667
17	$\frac{17}{60}$ths	0.2833	47	$\frac{47}{60}$ths	0.7833
18	$\frac{3}{10}$ths	0.30	48	$\frac{4}{5}$ths	0.80
19	$\frac{19}{60}$ths	0.3167	49	$\frac{49}{60}$ths	0.8167
20	$\frac{1}{3}$rd	0.333	50	$\frac{5}{6}$ths	0.8333
21	$\frac{7}{20}$ths	0.35	51	$\frac{51}{60}$ths	0.85
22	$\frac{11}{30}$ths	0.3667	52	$\frac{13}{15}$ths	0.8667
23	$\frac{23}{60}$ths	0.3833	53	$\frac{53}{60}$ths	0.8833
24	$\frac{2}{5}$ths	0.40	54	$\frac{9}{10}$ths	0.90
25	$\frac{5}{12}$ths	0.4167	55	$\frac{11}{12}$ths	0.9167
26	$\frac{13}{30}$ths	0.4333	56	$\frac{14}{15}$ths	0.9333
27	$\frac{9}{20}$ths	0.45	57	$\frac{19}{20}$ths	0.95
28	$\frac{7}{15}$ths	0.4667	58	$\frac{29}{30}$ths	0.9667
29	$\frac{29}{60}$ths	0.4833	59	$\frac{59}{60}$ths	0.9833
30	$\frac{1}{2}$	0.5	60	1	1.0

Example: Write 4 hours and 37 minutes in decimals. It would be written 4.6167.

Now find the labor cost for 4.6167 hrs. at \$1.12½ an hr.

Hours,	4.6167
Hourly Rate,	\$ 1.125
	230835
	92334
	46167
	46167

Total Cost, \$5.1937875 or \$5.19

Similar Decimals.—Decimals that have the same number of decimal places are called similar decimals. Thus, 0.75 and 0.25 are similar decimals and so are 0.150 and 0.275; but 0.15 and 0.275 are dissimilar decimals.

To reduce dissimilar decimals to similar decimals, give them the same number of decimal places by annexing or cutting off zeros. Example, 0.125, 0.25, 0.375 and 0.5 may all be reduced to thousandths as follows: 0.125, 0.250, 0.375 and 0.500.

To Reduce a Decimal to a Common Fraction.—Omit the decimal point, write the denominator of the decimal, and then reduce the common fraction to its lowest terms.

Example: 0.375 equals $\frac{375}{1000}$, which reduced to its lowest terms, equals $\frac{3}{8}$.

$$\frac{375}{1000} = \frac{15}{40} = \frac{3}{8}$$

How to Add Decimals.—To add numbers containing decimals, write like orders under one another, and then add as with whole numbers. Example, add 0.125, 0.25, 0.375, and 1.0.

The total of the addition is 1.750, which equals $1\frac{750}{1000}$, and which may be further reduced to $1\frac{3}{4}$

0.125
0.25
0.375
1.0
1.750

How to Subtract Decimals.—To subtract one number from another, when either or both contain decimals, reduce to similar decimals, write like orders under one another, and subtract as with whole numbers.

Subtract 20 hours and 37 minutes from 27 hours and 13 minutes, both being written in decimals. The difference is 6.6000 or 6.6 hours, which reduced to a common fraction is 6⅗ hours or 6 hours and 36 minutes.

27.2167
20.6167
6.6000

How to Multiply Decimals.—The same method is used as in multiplying other numbers, and the result should contain as many decimal points as there are in both of the numbers multiplied.

Example: Multiply 3 feet 6 inches by 4 feet 9 inches

4 ft. 9 in.=4′-9″=4¾ ft.=4.75 Multiplicand

3 ft. 6 in.=3′-6″=3½ ft.=3.5 Multiplier

To multiply, proceed as illustrated

	4.75
	3.5
	2375
	1425
Product	16625 or 16.625

In the above example, there are 2 decimals in the multiplicand and 1 decimal in the multiplier. The result or product should contain the same number of decimals as the multiplicand and multiplier combined, which is three. Starting at the right and counting to the left three places, place the decimal point between the two sixes. The result would be 16.625, which equals $16\frac{625}{1000}=16\frac{5}{8}$ sq. ft.

Practical Examples Using Decimals

The quantities of cement, sand and gravel required for one cu. yd. of concrete are ordinarily stated in decimals: For instance, a cu. yd. of concrete mixed in the proportions of 1 part cement; 2 parts sand; and 4 parts gravel, is usually stated 1:2:4 and requires the following materials:

1.50 bbls. cement $=1\frac{50}{100}$ bbls. $=1\frac{1}{2}$ bbls. $=6$ sacks.

0.42 cu. yds. sand $=\frac{42}{100}$ cu. yds. $=\frac{21}{50}$ cu. yds. $=11\frac{1}{3}$ cu. ft.

0.84 cu. yds. gravel $=\frac{84}{100}$ cu. yds. $=\frac{21}{25}$ cu. yds. $=22\frac{2}{3}$ cu. ft.

There are 4 sacks of cement to the bbl., and each sack weighs 94 lbs. and contains approximately 1 cu. ft. of cement.

There are 27 cu. ft. in a cu. yd.; to obtain the number of cu. ft. of sand required for a yard of concrete, refer to the table, 0.42 cu. yds. $=\frac{42}{100}$ cu. yds. $=\frac{21}{50}$ cu. yds. and $\frac{21}{50}$ of 27

$$\text{cu. ft.} = \frac{21 \times 27}{50} = \frac{567}{50}.$$ 567÷50=11.34 or $11\frac{1}{3}$ cu. ft. sand.

To find the cost of a cu. yd. of concrete based on the above quantities, and assuming it requires 2¼ hrs. labor time to mix and place one cu. yd. of concrete, proceed as follows:

1½ bbls. cement	= 1.50 bbls. cement	@ $6.00 per bbl.	= 9.0000
11⅓ cu. ft. sand	= 0.42 cu. yd. sand	@ $4.13 per cu. yd.	= 1.7346
22⅔ cu. ft. gravel	= 0.84 cu. yd. gravel	@ $3.78 per cu. yd.	= 3.1752
2¼ hrs. labor	= 2.25 hrs. labor	@ $3.30 per hr.	= 7.4250
Cost per cu. yd.			$21.3348

You will note the total is carried in four decimal places. This is to illustrate the actual figures obtained by multiplying. The total would be $21.33 per cu. yd. of concrete.

In making the above multiplications you will note there are 2 decimals in both the multiplicand and the multiplier of all the

amounts multiplied, so the result should contain as many decimals as the sum of the multiplicand and multiplier, which is 4. You will note all the totals contain 4 decimal places. Always bear this in mind when making your multiplications because if the decimal place is wrong it makes a difference of 90 percent in your total. You know the correct result is $21.3348, but suppose by mistake you counted off 5 decimal places. The result would be $2.13348 or $2.13 per cu. yd. or just about 1/10 enough; or if you made a mistake the other way and counted off just 3 decimal places, the result would be $213.348 or $213.35 per cu. yd., or just about 10 times too much. Watch your decimal places.

The same method is used in estimating lumber. All kinds of framing lumber are ordinarily sold by the 1,000 ft., b.m., so 1,000 is the unit or decimal used when estimating lumber.

Suppose you buy 150 pcs. of 2"x8"-16'-0', which contains 3,200 ft. b. m. This is equivalent to $3\frac{200}{1000}=3\frac{2}{10}=3\frac{1}{5}$ thousandths or stated in decimals it may be either 3.2 or 3.200. The cost of this lumber at $135.00 per 1,000 ft. b. m., would be obtained by multiplying 3.200 ft. at $135.00 per 1,000 ft. b. m. as follows: 3.200 M ft. of lumber @ $135.00 = $432.00000 or $432.00.

Note there were 3 decimal places in the multiplicand and 2 decimal places in the multiplier, so the result should contain 5 decimal places, but inasmuch as all the decimals are zeros, drop all but two of them to designate 432 dollars and no cents.

Things to Remember When Using Decimals

. at the left of a figure indicates a decimal.
.6 indicates tenths, thus $.6=\frac{6}{10}=.60=\frac{60}{100}=.600=\frac{600}{1000}$
.06 indicates hundredths, thus $.06=\frac{6}{100}=.060=\frac{60}{1000}$
.006 indicates thousandths, thus $.006=\frac{6}{1000}$
.0006 indicates ten thousandths, thus $.0006=\frac{6}{10000}$

When multiplying decimals always remember that the result or product must contain as many decimal places as the sum of the decimal places in both the multiplicand and the multiplier; thus: Find the cost of 3 hrs. 20 min. laborer's time at $2.42½ an hr.

3 hrs. 20 min. equal 3⅓ hrs. =3.333 Multiplicand
2 dollars 42½ cents an hr. =2.425 Multiplier

There are 3 decimals in the multiplicand and 3 decimals in the multiplier, so the result or total should contain as many decimals as the sum of the multiplicand and multiplier, which is 6.

16665
6666
13332
6666
8082525=8.082525=$8.08

Be sure your decimal point is in the RIGHT place and the rest is easy.

CONVERSION FACTORS

Metric—English Systems

Multiply	by	to obtain
acres	0.404687	hectares
"	4.04687×10^{-3}	square kilometers
ares	1076.39	square feet
board feet	144 sq in. × 1 in.	cubic inches
" "	0.0833	cubic feet
bushels	0.3521	hectoliters
centimeters	3.28083×10^{-2}	feet
"	0.3937	inches
cubic centimeters	3.53145×10^{-5}	cubic feet
" "	6.102×10^{-2}	cubic inches
cubic feet	2.8317×10^{4}	cubic centimeters
" "	2.8317×10^{-2}	cubic meters
" "	6.22905	gallons, Imperial
" "	0.2832	hectoliters
" "	28.3170	liters
" "	2.38095×10^{-2}	tons, British shipping
" "	0.025	tons, U.S. shipping
cubic inches	16.38716	cubic centimeters
cubic meters	35.3145	cubic feet
" "	1.30794	cubic yards
" "	264.2	gallons, U. S.
cubic yards	0.764559	cubic meters
" "	7.6336	hectoliters
degrees, angular	0.0174533	radians
degrees, F (less 32 F)	0.5556	degrees, C
" C	1.8	degrees, F (less 32 F)
foot pounds	0.13826	kilogram meters
feet	30.4801	centimeters
"	0.304801	meters
"	304.801	millimeters
"	1.64468×10^{-4}	miles, nautical
gallons, Imperial	0.160538	cubic feet
" "	1.20091	gallons, U. S.
" "	4.54596	liters
gallons, U.S.	0.832702	gallons, Imperial
" "	0.13368	cubic feet
" "	231.	cubic inches
" "	0.0378	hectoliters
" "	3.78543	liters
grams, metric	2.20462×10^{-3}	pounds, avoirdupois
hectares	2.47104	acres
"	1.076387×10^{5}	square feet

Conversion Factors (Cont'd)

Multiply	by	to obtain
hectares	3.86101×10^{-3}	square miles
hectoliters	3.531	cubic feet
"	2.84	bushels
"	0.131	cubic yards
hectoliters	26.42	gallons
horsepower, metric	0.98632	horsepower, U. S.
horsepower, U.S.	1.01387	horsepower, metric
inches	2.54001	centimeters
"	2.54001×10^{-2}	meters
"	25.4001	millimeters
kilograms	2.20462	pounds
"	9.84206×10^{-4}	long tons
"	1.10231×10^{-3}	short tons
kilogram meters	7.233	foot pounds
kilograms per m	0.671972	pounds per ft
kilograms per sq cm	14.2234	pounds per sq in.
kilograms per sq m	0.204817	pounds per sq ft
" " " "	9.14362×10^{-5}	long tons per sq ft
kilograms per sq mm	1422.34	ponnds per sq in.
" " " "	0.634973	long tons per sq in.
kilograms per cu m	6.24283×10^{-2}	pounds per cu ft
kilometers	0.62137	miles, statute
"	0.53959	miles, nautical
"	3280.7	feet
liters	0.219975	gallons, Imperial
"	0.26417	gallons, U.S.
"	3.53145×10^{-2}	cubic feet
"	61.022	cubic inches
meters	3.28083	feet
"	39.37	inches
"	1.09361	yards
miles, statute	1.60935	kilometers
" "	0.8684	miles, nautical
miles, nautical	6080.204	feet
" "	1.85325	kilometers
" "	1.1516	miles, statute
millimeters	3.28083×10^{-3}	feet
"	3.937×10^{-2}	inches
pounds, avoirdupois	453.592	grams, metric
" "	0.453592	kilograms
" "	4.464×10^{-4}	tons, long
" "	4.53592×10^{-4}	tons, metric
pounds per ft	1.48816	kilograms per m

Conversion Factors (Cont'd)

Multiply	by	to obtain
pounds per sq ft	4.88241	kilograms per sq m
pounds per sq in.	7.031×10^{-2}	kilograms per sq cm
" " " "	7.031×10^{-4}	kilograms per sq mm
pounds per cu ft	16.0184	kilograms per cu m
radians	57.29578	degrees, angular
square centimeters	0.1550	square inches
square feet	9.29034×10^{-4}	ares
square feet	9.29034×10^{-6}	hectares
" "	0.0929034	square meters
square inches	6.45163	square centimeters
" "	645.163	square millimeters
square kilometers	247.104	acres
" "	0.3861	square miles
square meters	10.7639	square feet
" "	1.19599	square yards
square miles	259.0	hectares
" "	2.590	square kilometers
square millimeters	1.550×10^{-3}	square inches
square yards	0.83613	square meters
tons, long	1016.05	kilograms
" "	2240.	pounds
" "	1.01605	tons, metric
" "	1.120	tons, short
tons, long, per sq ft	1.09366×10^{-4}	kilograms per sq m
tons, long, per sq in.	1.57494	kilograms per sq mm
tons, metric	2204.62	pounds
" "	0.98421	tons, long
" "	1.10231	tons, short
tons, short	907.185	kilograms
" "	0.892857	tons, long
" "	0.907185	tons, metric
tons, British shipping	42.00	cubic feet
" " "	0.952381	tons, U. S. shipping
tons, U. S. shipping	40.00	cubic feet
" " "	1.050	tons, British shipping
yards	0.914402	meters

FUNCTIONS OF NUMBERS, 1 TO 49

No.	Square	Cube	Square Root	Cubic Root	Logarithm
1	1	1	1.0000	1.0000	0.00000
2	4	8	1.4142	1.2599	0.30103
3	9	27	1.7321	1.4422	0.47712
4	16	64	2.0000	1.5874	0.60206
5	25	125	2.2361	1.7100	0.69897
6	36	216	2.4495	1.8171	0.77815
7	49	343	2.6458	1.9129	0.84510
8	64	512	2.8284	2.0000	0.90309
9	81	729	3.0000	2.0801	0.95424
10	100	1000	3.1623	2.1544	1.00000
11	121	1331	3.3166	2.2240	1.04139
12	144	1728	3.4641	2.2894	1.07918
13	169	2197	3.6056	2.3513	1.11394
14	196	2744	3.7417	2.4101	1.14613
15	225	3375	3.8730	2.4662	1.17609
16	256	4096	4.0000	2.5198	1.20412
17	289	4913	4.1231	2.5713	1.23045
18	324	5832	4.2426	2.6207	1.25527
19	361	6859	4.3589	2.6684	1.27875
20	400	8000	4.4721	2.7144	1.30103
21	441	9261	4.5826	2.7589	1.32222
22	484	10648	4.6904	2.8020	1.34242
23	529	12167	4.7958	2.8439	1.36173
24	576	13824	4.8990	2.8845	1.38021
25	625	15625	5.0000	2.9240	1.39794
26	676	17576	5.0990	2.9625	1.41497
27	729	19683	5.1962	3.0000	1.43136
28	784	21952	5.2915	3.0366	1.44716
29	841	24389	5.3852	3.0723	1.46240
30	900	27000	5.4772	3.1072	1.47712
31	961	29791	5.5678	3.1414	1.49136
32	1024	32768	5.6569	3.1748	1.50515
33	1089	35937	5.7446	3.2075	1.51851
34	1156	39304	5.8310	3.2396	1.53148
35	1225	42875	5.9161	3.2711	1.54407
36	1296	46656	6.0000	3.3019	1.55630
37	1369	50653	6.0828	3.3322	1.56820
38	1444	54872	6.1644	3.3620	1.57978
39	1521	59319	6.2450	3.3912	1.59106
40	1600	64000	6.3246	3.4200	1.60206
41	1681	68921	6.4031	3.4482	1.61278
42	1764	74088	6.4807	3.4760	1.62325
43	1849	79507	6.5574	3.5034	1.63347
44	1936	85184	6.6332	3.5303	1.64345
45	2025	91125	6.7082	3.5569	1.65321
46	2116	97336	6.7823	3.5830	1.66276
47	2209	103823	6.8557	3.6088	1.67210
48	2304	110592	6.9282	3.6342	1.68124
49	2401	117649	7.0000	3.6593	1.69020

FUNCTIONS OF NUMBERS, 50 TO 99

No.	Square	Cube	Square Root	Cubic Root	Logarithm
50	2500	125000	7.0711	3 6840	1.69897
51	2601	132651	7.1414	3.7084	1 70757
52	2704	140608	7.2111	3.7325	1.71600
53	2809	148877	7.2801	3.7563	1.72428
54	2916	157464	7.3485	3.7798	1.73239
55	3025	166375	7.4162	3.8030	1.74036
56	3136	175616	7.4833	3.8259	1.74819
57	3249	185193	7.5498	3.8485	1.75587
58	3364	195112	7.6158	3.8709	1.76343
59	3481	205379	7.6811	3.8930	1.77085
60	3600	216000	7.7460	3.9149	1.77815
61	3721	226981	7.8102	3.9365	1.78533
62	3844	238328	7.8740	3.9579	1.79239
63	3969	250047	7.9373	3.9791	1.79934
64	4096	262144	8.0000	4.0000	1.80618
65	4225	274625	8.0623	4.0207	1.81291
66	4356	287496	8.1240	4.0412	1.81954
67	4489	300763	8.1854	4.0615	1.82607
68	4624	314432	8.2462	4.0817	1.83251
69	4761	328509	8.3066	4.1016	1.83885
70	4900	343000	8.3666	4.1213	1.84510
71	5041	357911	8 4261	4.1408	1.85126
72	5184	373248	8.4853	4.1602	1.85733
73	5329	389017	8.5440	4.1793	1.86332
74	5476	405224	8.6023	4.1983	1.86923
75	5625	421875	8.6603	4.2172	1.87506
76	5776	438976	8.7178	4.2358	1.88081
77	5929	456533	8.7750	4.2543	1.88649
78	6084	474552	8.8318	4.2727	1.89209
79	6241	493039	8.8882	4.2908	1.89763
80	6400	512000	8.9443	4.3089	1.90309
81	6561	531441	9.0000	4.3267	1.90849
82	6724	551368	9.0554	4.3445	1.91381
83	6889	571787	9.1104	4.3621	1.91908
84	7056	592704	9.1652	4.3795	1.92428
85	7225	614125	9.2195	4.3968	1.92942
86	7396	636056	9.2736	4.4140	1.93450
87	7569	658503	9.3274	4.4310	1.93952
88	7744	681472	9.3808	4.4480	1.94448
89	7921	704969	9.4340	4.4647	1.94939
90	8100	729000	9.4868	4.4814	1.95424
91	8281	753571	9.5394	4.4979	1.95904
92	8464	778688	9.5917	4.5144	1.96379
93	8649	804357	9.6437	4.5307	1.96848
94	8836	830584	9.6954	4.5468	1.97313
95	9025	857375	9.7468	4.5629	1.97772
96	9216	884736	9.7980	4.5789	1.98227
97	9409	912673	9.8489	4.5947	1.98677
98	9604	941192	9.8995	4.6104	1.99123
99	9801	970299	9.9499	4.6261	1.99564

FUNCTIONS OF NUMBERS, 100 TO 149

No.	Square	Cube	Square Root	Cubic Root	Logarithm
100	10000	1000000	10.0000	4 6416	2.00000
101	10201	1030301	10 0499	4 6570	2.00432
102	10404	1061208	10.0995	4 6723	2.00860
103	10609	1092727	10.1489	4 6875	2 01284
104	10816	1124864	10 1980	4 7027	2 01703
105	11025	1157625	10.2470	4 7177	2 02119
106	11236	1191016	10.2956	4 7326	2 02531
107	11449	1225043	10.3441	4 7475	2 02938
108	11664	1259712	10.3923	4.7622	2 03342
109	11881	1295029	10.4403	4.7769	2 03743
110	12100	1331000	10.4881	4.7914	2 04139
111	12321	1367631	10.5357	4.8059	2.04532
112	12544	1404928	10.5830	4.8203	2.04922
113	12769	1442897	10 6301	4.8346	2 05308
114	12996	1481544	10.6771	4.8488	2 05690
115	13225	1520875	10.7238	4.8629	2 06070
116	13456	1560896	10.7703	4 8770	2 06446
117	13689	1601613	10.8167	4.8910	2.06819
118	13924	1643032	10.8628	4.9049	2 07188
119	14161	1685159	10.9087	4.9187	2 07555
120	14400	1728000	10.9545	4.9324	2 07918
121	14641	1771561	11.0000	4.9461	2.08279
122	14884	1815848	11 0454	4.9597	2 08636
123	15129	1860867	11 0905	4.9732	2.08991
124	15376	1906624	11.1355	4 9866	2.09342
125	15625	1953125	11.1803	5.0000	2 09691
126	15876	2000376	11 2250	5 0133	2 10037
127	16129	2048383	11.2694	5.0265	2 10380
128	16384	2097152	11.3137	5 0397	2.10721
129	16641	2146689	11.3578	5.0528	2 11059
130	16900	2197000	11.4018	5.0658	2 11394
131	17161	2248091	11.4455	5 0788	2 11727
132	17424	2299968	11.4891	5.0916	2 12057
133	17689	2352637	11.5326	5.1045	2 12385
134	17956	2406104	11 5758	5 1172	2 12710
135	18225	2460375	11.6190	5 1299	2 13033
136	18496	2515456	11.6619	5 1426	2 13354
137	18769	2571353	11.7047	5 1551	2 13672
138	19044	2628072	11.7473	5.1676	2 13988
139	19321	2685619	11.7898	5.1801	2 14301
140	19600	2744000	11.8322	5.1925	2 14613
141	19881	2803221	11.8743	5.2048	2 14922
142	20164	2863288	11 9164	5 2171	2 15229
143	20449	2924207	11 9583	5 2293	2 15534
144	20736	2985984	12 0000	5 2415	2 15836
145	21025	3048625	12 0416	5 2536	2 16137
146	21316	3112136	12 0830	5 2656	2 16435
147	21609	3176523	12 1244	5 2776	2 16732
148	21904	3241792	12 1655	5 2896	2 17026
149	22201	3307949	12.2066	5 3015	2 17319

FUNCTIONS OF NUMBERS, 150 TO 199

No.	Square	Cube	Square Root	Cubic Root	Logarithm
150	22500	3375000	12.2474	5.3133	2.17609
151	22801	3442951	12 2882	5.3251	2.17898
152	23104	3511808	12 3288	5.3368	2.18184
153	23409	3581577	12.3693	5.3485	2.18469
154	23716	3652264	12 4097	5.3601	2.18752
155	24025	3723875	12 4499	5.3717	2.19033
156	24336	3796416	12 4900	5.3832	2.19312
157	24649	3869893	12 5300	5.3947	2 19590
158	24964	3944312	12 5698	5.4061	2.19866
159	25281	4019679	12.6095	5.4175	2.20140
160	25600	4096000	12 6491	5.4288	2.20412
161	25921	4173281	12 6886	5.4401	2.20683
162	26244	4251528	12.7279	5.4514	2.20952
163	26569	4330747	12 7671	5.4626	2.21219
164	26896	4410944	12.8062	5.4737	2.21484
165	27225	4492125	12.8452	5.4848	2.21748
166	27556	4574296	12.8841	5.4959	2.22011
167	27889	4657463	12 9228	5.5069	2.22272
168	28224	4741632	12.9615	5 5178	2.22531
169	28561	4826809	13.0000	5.5288	2.22789
170	28900	4913000	13.0384	5.5397	2.23045
171	29241	5000211	13.0767	5.5505	2.23300
172	29584	5088448	13.1149	5.5613	2.23553
173	29929	5177717	13.1529	5.5721	2.23805
174	30276	5268024	13 1909	5.5828	2.24055
175	30625	5359375	13.2288	5.5934	2.24304
176	30976	5451776	13.2665	5.6041	2 24551
177	31329	5545233	13.3041	5.6147	2.24797
178	31684	5639752	13.3417	5.6252	2.25042
179	32041	5735339	13.3791	5 6357	2.25285
180	32400	5832000	13 4164	5 6462	2.25527
181	32761	5929741	13.4536	5.6567	2.25768
182	33124	6028568	13.4907	5.6671	2.26007
183	33489	6128487	13 5277	5.6774	2.26245
184	33856	6229504	13 5647	5.6877	2.26482
185	34225	6331625	13 6015	5.6980	2.26717
186	34596	6434856	13.6382	5 7083	2.26951
187	34969	6539203	13.6748	5.7185	2 27184
188	35344	6644672	13 7113	5 7287	2 27416
189	35721	6751269	13 7477	5 7388	2.27646
190	36100	6859000	13 7840	5 7489	2.27875
191	36481	6967871	13 8203	5.7590	2.28103
192	36864	7077888	13 8564	5.7690	2.28330
193	37249	7189057	13 8924	5.7790	2 28556
194	37636	7301384	13 9284	5 7890	2.28780
195	38025	7414875	13 9642	5 7989	2.29003
196	38416	7529536	14 0000	5 8088	2.29226
197	38809	7645373	14 0357	5 8186	2 29447
198	39204	7762392	14 0712	5 8285	2.29667
199	39601	7880599	14 1067	5 8383	2.29885

FUNCTIONS OF NUMBERS, 200 TO 249

No.	Square	Cube	Square Root	Cubic Root	Logarithm
200	40000	8000000	14.1421	5.8480	2.30103
201	40401	8120601	14.1774	5.8578	2.30320
202	40804	8242408	14.2127	5.8675	2.30535
203	41209	8365427	14.2478	5.8771	2.30750
204	41616	8489664	14 2829	5.8868	2.30963
205	42025	8615125	14.3178	5.8964	2.31175
206	42436	8741816	14.3527	5.9059	2.31387
207	42849	8869743	14.3875	5.9155	2.31597
208	43264	8998912	14.4222	5.9250	2.31806
209	43681	9129329	14.4568	5.9345	2.32015
210	44100	9261000	14.4914	5.9439	2.32222
211	44521	9393931	14.5258	5.9533	2.32428
212	44944	9528128	14 5602	5.9627	2.32634
213	45369	9663597	14.5945	5.9721	2.32838
214	45796	9800344	14.6287	5.9814	2.33041
215	46225	9938375	14.6629	5.9907	2.33244
216	46656	10077696	14.6969	6.0000	2.33445
217	47089	10218313	14.7309	6.0092	2.33646
218	47524	10360232	14.7648	6.0185	2.33846
219	47961	10503459	14.7986	6.0277	2.34044
220	48400	10648000	14.8324	6.0368	2.34242
221	48841	10793861	14.8661	6.0459	2.34439
222	49284	10941048	14.8997	6.0550	2.34635
223	49729	11089567	14.9332	6.0641	2.34830
224	50176	11239424	14.9666	6.0732	2.35025
225	50625	11390625	15.0000	6.0822	2.35218
226	51076	11543176	15.0333	6.0912	2.35411
227	51529	11697083	15.0665	6.1002	2.35603
228	51984	11852352	15.0997	6.1091	2.35793
229	52441	12008989	15.1327	6.1180	2.35984
230	52900	12167000	15.1658	6.1269	2.36173
231	53361	12326391	15.1987	6.1358	2.36361
232	53824	12487168	15.2315	6.1446	2.36549
233	54289	12649337	15.2643	6.1534	2.36736
234	54756	12812904	15.2971	6.1622	2.36922
235	55225	12977875	15.3297	6.1710	2.37107
236	55696	13144256	15.3623	6.1797	2.37291
237	56169	13312053	15.3948	6.1885	2.37475
238	56644	13481272	15.4272	6.1972	2.37658
239	57121	13651919	15.4596	6.2058	2.37840
240	57600	13824000	15.4919	6.2145	2.38021
241	58081	13997521	15.5242	6·2231	2.38202
242	58564	14172488	15.5563	6.2317	2.38382
243	59049	14348907	15.5885	6.2403	2.38561
244	59536	14526784	15.6205	6.2488	2.38739
245	60025	14706125	15.6525	6.2573	2.38917
246	60516	14886936	15.6844	6.2658	2.39094
247	61009	15069223	15.7162	6.2743	2.39270
248	61504	15252992	15.7480	6.2828	2.39445
249	62001	15438249	15.7797	6.2912	2.39620

FUNCTIONS OF NUMBERS, 250 TO 299

No.	Square	Cube	Square Root	Cubic Root	Logarithm
250	62500	15625000	15.8114	6.2996	2.39794
251	63001	15813251	15.8430	6.3080	2.39967
252	63504	16003008	15.8745	6.3164	2.40140
253	64009	16194277	15.9060	6.3247	2.40312
254	64516	16387064	15.9374	6.3330	2.40483
255	65025	16581375	15.9687	6.3413	2.40654
256	65536	16777216	16.0000	6.3496	2.40824
257	66049	16974593	16.0312	6.3579	2.40993
258	66564	17173512	16.0624	6.3661	2.41162
259	67081	17373979	16.0935	6.3743	2.41330
260	67600	17576000	16.1245	6.3825	2.41497
261	68121	17779581	16.1555	6.3907	2.41664
262	68644	17984728	16.1864	6.3988	2.41830
263	69169	18191447	16.2173	6.4070	2.41996
264	69696	18399744	16.2481	6.4151	2.42160
265	70225	18609625	16.2788	6.4232	2.42325
266	70756	18821096	16.3095	6.4312	2.42488
267	71289	19034163	16.3401	6.4393	2.42651
268	71824	19248832	16.3707	6.4473	2.42813
269	72361	19465109	16.4012	6.4553	2.42975
270	72900	19683000	16.4317	6.4633	2.43136
271	73441	19902511	16.4621	6.4713	2.43297
272	73984	20123648	16.4924	6.4792	2.43457
273	74529	20346417	16.5227	6.4872	2.43616
274	75076	20570824	16.5529	6.4951	2.43775
275	75625	20796875	16.5831	6.5030	2.43933
276	76176	21024576	16.6132	6.5108	2.44091
277	76729	21253933	16.6433	6.5187	2.44248
278	77284	21484952	16.6733	6.5265	2.44404
279	77841	21717639	16.7033	6.5343	2.44560
280	78400	21952000	16 7332	6.5421	2.44716
281	78961	22188041	16.7631	6.5499	2.44871
282	79524	22425768	16.7929	6.5577	2.45025
283	80089	22665187	16.8226	6.5654	2.45179
284	80656	22906304	16.8523	6.5731	2.45332
285	81225	23149125	16.8819	6.5808	2.45484
286	81796	23393656	16.9115	6.5885	2 45637
287	82369	23639903	16.9411	6.5962	2 45788
288	82944	23887872	16.9706	6.6039	2 45939
289	83521	24137569	17.0000	6.6115	2 46090
290	84100	24389000	17.0294	6.6191	2.46240
291	84681	24642171	17.0587	6.6267	2.46389
292	85264	24897088	17 0880	6.6343	2.46538
293	85849	25153757	17 1172	6.6419	2.46687
294	86436	25412184	17 1464	6.6494	2.46835
295	87025	25672375	17 1756	6.6569	2.46982
296	87616	25934336	17 2047	6.6644	2.47129
297	88209	26198073	17 2337	6.6719	2.47276
298	88804	26463592	17.2627	6 6794	2.47422
299	89401	26730899	17.2916	6.6869	2.47567

FUNCTIONS OF NUMBERS, 300 TO 349

No.	Square	Cube	Square Root	Cubic Root	Logarithm
300	90000	27000000	17.3205	6.6943	2.47712
301	90601	27270901	17.3494	6.7018	2.47857
302	91204	27543608	17 3781	6.7092	2.48001
303	91809	27818127	17.4069	6.7166	2.48144
304	92416	28094464	17.4356	6.7240	2.48287
305	93025	28372625	17.4642	6.7313	2.48430
306	93636	28652616	17.4929	6.7387	2.48572
307	94249	28934443	17.5214	6.7460	2.48714
308	94864	29218112	17.5499	6.7533	2.48855
309	95481	29503629	17.5784	6.7606	2.48996
310	96100	29791000	17 6068	6.7679	2.49136
311	96721	30080231	17 6352	6.7752	2.49276
312	97344	30371328	17 6635	6.7824	2.49415
313	97969	30664297	17 6918	6.7897	2.49554
314	98596	30959144	17 7200	6.7969	2.49693
315	99225	31255875	17.7482	6.8041	2.49831
316	99856	31554496	17 7764	6.8113	2.49969
317	100489	31855013	17 8045	6.8185	2.50106
318	101124	32157432	17 8326	6.8256	2.50243
319	101761	32461759	17.8606	6.8328	2.50379
320	102400	32768000	17.8885	6.8399	2.50515
321	103041	33076161	17.9165	6.8470	2.50651
322	103684	33386248	17.9444	6.8541	2.50786
323	104329	33698267	17.9722	6.8612	2.50920
324	104976	34012224	18.0000	6.8683	2.51055
325	105625	34328125	18.0278	6.8753	2.51188
326	106276	34645976	18.0555	6.8824	2.51322
327	106929	34965783	18.0831	6.8894	2.51455
328	107584	35287552	18.1108	6.8964	2.51587
329	108241	35611289	18.1384	6.9034	2.51720
330	108900	35937000	18.1659	6.9104	2.51851
331	109561	36264691	18 1934	6.9174	2.51983
332	110224	36594368	18.2209	6.9244	2.52114
333	110889	36926037	18.2483	6.9313	2.52244
334	111556	37259704	18.2757	6.9382	2.52375
335	112225	37595375	18.3030	6 9451	2.52504
336	112896	37933056	18.3303	6.9521	2.52634
337	113569	38272753	18 3576	6.9589	2.52763
338	114244	38614472	18.3848	6 9658	2.52892
339	114921	38958219	18.4120	6.9727	2.53020
340	115600	39304000	18.4391	6.9795	2.53148
341	116281	39651821	18.4662	6.9864	2.53275
342	116964	40001688	18 4932	6 9932	2.53403
343	117649	40353607	18 5203	7 0000	2.53529
344	118336	40707584	18 5472	7.0068	2.53656
345	119025	41063625	18 5742	7 0136	2.53782
346	119716	41421736	18 6011	7.0203	2.53908
347	120409	41781923	18 6279	7.0271	2.54033
348	121104	42144192	18 6548	7.0338	2.54158
349	121801	42508549	18 6815	7.0406	2.54283

FUNCTIONS OF NUMBERS, 350 TO 399

No.	Square	Cube	Square Root	Cubic Root	Logarithm
350	122500	42875000	18.7083	7.0473	2.54407
351	123201	43243551	18.7350	7.0540	2.54531
352	123904	43614208	18.7617	7.0607	2.54654
353	124609	43986977	18.7883	7.0674	2.54777
354	125316	44361864	18.8149	7.0740	2.54900
355	126025	44738875	18.8414	7.0807	2.55023
356	126736	45118016	18.8680	7.0873	2.55145
357	127449	45499293	18.8944	7.0940	2.55267
358	128164	45882712	18.9209	7.1006	2.55388
359	128881	46268279	18.9473	7.1072	2.55509
360	129600	46656000	18.9737	7.1138	2.55630
361	130321	47045881	19 0000	7.1204	2.55751
362	131044	47437928	19.0263	7.1269	2.55871
363	131769	47832147	19.0526	7.1335	2.55991
364	132496	48228544	19 0788	7.1400	2.56110
365	133225	48627125	19.1050	7.1466	2.56229
366	133956	49027896	19.1311	7.1531	2.56348
367	134689	49430863	19.1572	7.1596	2.56467
368	135424	49836032	19.1833	7.1661	2.56585
369	136161	50243409	19.2094	7.1726	2.56703
370	136900	50653000	19.2354	7.1791	2.56820
371	137641	51064811	19.2614	7.1855	2.56937
372	138384	51478848	19.2873	7.1920	2.57054
373	139129	51895117	19.3132	7 1984	2.57171
374	139876	52313624	19.3391	7.2048	2.57287
375	140625	52734375	19.3649	7.2112	2.57403
376	141376	53157376	19.3907	7.2177	2.57519
377	142129	53582633	19.4165	7.2240	2.57634
378	142884	54010152	19.4422	7.2304	2.57749
379	143641	54439939	19.4679	7.2368	2.57864
380	144400	54872000	19.4936	7.2432	2.57978
381	145161	55306341	19.5192	7.2495	2.58093
382	145924	55742968	19.5448	7.2558	2.58206
383	146689	56181887	19.5704	7.2622	2.58320
384	147456	56623104	19.5959	7.2685	2.58433
385	148225	57066625	19.6214	7.2748	2.58546
386	148996	57512456	19.6469	7.2811	2.58659
387	149769	57960603	19.6723	7.2874	2.58771
388	150544	58411072	19.6977	7.2936	2.58883
389	151321	58863869	19.7231	7.2999	2.58995
390	152100	59319000	19.7484	7.3061	2.59106
391	152881	59776471	19.7737	7.3124	2.59218
392	153664	60236288	19.7990	7.3186	2.59329
393	154449	60698457	19.8242	7.3248	2.59439
394	155236	61162984	19.8494	7.3310	2.59550
395	156025	61629875	19.8746	7.3372	2.59660
396	156816	62099136	19.8997	7.3434	2.59770
397	157609	62570773	19.9249	7.3496	2.59879
398	158404	63044792	19.9499	7.3558	2.59988
399	159201	63521199	19.9750	7.3619	2.60097

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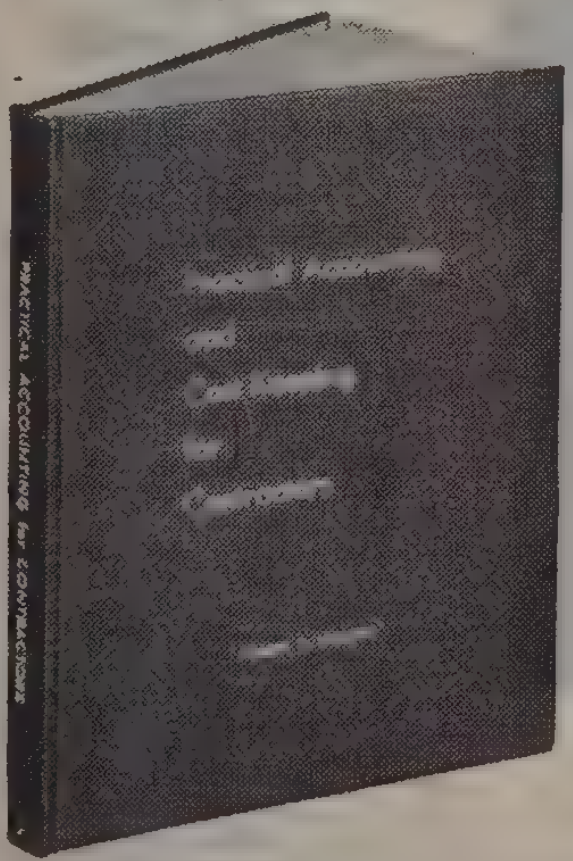

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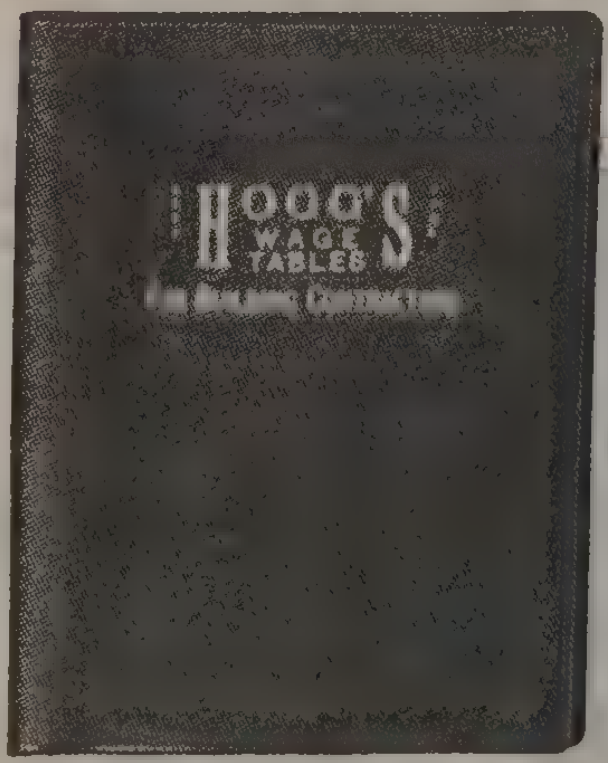

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